AGRICULTURAL ENGINEERING

JUNE • 1950

A.S.A.E. Annual Meeting • Washington, D. C., June 19 to 21

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

AGRICULTURAL ENGINEERING

Established 1920

CONTENTS FOR JUNE, 1950

Vol. 31, No. 6

AGRICULTURAL ENGINEERING is indexed regularly by Engineering Index, Inc.

INDEX TO ADVERTISERS

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AGRICULTURAL ENGINEERING is owned, edited, and published monthly by the American Society of Agricultural Engineers. The editorial, subscription and advertising departments are at the executive office of the Society, Saint Joseph, Michigan.

OFFICERS AND COUNCIL OF THE A.S.A.E.

SUBSCRIPTION PRICE: $4.00 a year, plus an extra postage charge to all countries to which the second-class postage rate does not apply; to ASAE members anywhere, $2.00 a year. Single copies (current), 40 cents each.

POST OFFICE ENTRY: Entered as second-class matter, October 28, 1933, at the post office at Benton Harbor, Michigan, under the Act of August 24, 1912. Additional entry at St. Joseph, Michigan. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921.

AGRICULTURAL ENGINEERING is a member of the Audit Bureau of Circulations.

ADVERTISING REPRESENTATIVES

Chicago 2: DWIGHT H. EARLY
100 North LaSalle St.
Tel. CEntral 6-2184

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RAYMOND OLNEY
Editor and Business Manager
505 Pleasant St., St. Joseph, Michigan
Telephone: 3-2700

EDITORIAL

Merchandising Aids Engineering

SO MUCH is said to and among engineers about the contributions of engineering to our modern life, that it seems timely to reflect on some of the other members of our economic team which help engineers to work effectively.

Recently we have been particularly impressed by the interdependence of merchandising and engineering. Good merchandising produces the quantity sales which support the quantity production in which engineering shows up to best advantage.

Most engineered products useful in agriculture can be made available at acceptable prices only through the economies of quantity production and quantity distribution.

Many merchandisers of farm equipment and supplies may not know a co-ordinate from a coefficient. Many of them do know how to help farmers see what products can be used to advantage to do specific jobs under characteristic conditions on individual farms. They know how to help farmers buy, finance, install, adjust, use, maintain, and service manufactured products, with resulting increased satisfaction, earning power, and added purchases.

They are helping farmers to make the most of the quality value engineered into farm equipment and supplies, to buy these items at prices made possible only by quantity production and sales, to develop confidence in the engineering back of those products, to think in terms of living and farming effectively.

They are selling some principles and practices, as well as products of agricultural engineering. They are creating acceptance for agricultural engineering; more and better jobs for agricultural engineers. They are selling engineering concepts of conservation and effective use of human and natural resources. They are our coworkers in encouraging farmers to help themselves by increasing their net output of genuine economic service.

Instrumentation

SOME agricultural engineers, particularly in the field of research, have recently indicated that instrumentation warrants increased attention as an aid to technical progress in agricultural engineering.

The need of attention arises from rapid progress in the field of instrumentation, rather than from a lack of progress. It creates for agricultural engineers a problem of keeping reasonably up to date on the types and variations of instruments available for their use, the characteristics and limitations of a wide range of instruments, the instrumentation techniques which have been used successfully on a wide variety of problems, and the difficulties to be anticipated in securing accurate results from various types of instruments.

Agricultural engineers cannot afford to handicap their work with less than the best instrumentation readily available, nor to duplicate a lot of instrument development work which has already been done. Neither can they afford to overlook opportunities to improve on available instruments for their special purposes.

The time, trouble, and cost of instrumentation, and losses due to less than the best instrumentation for the job at hand, are costs which must be deducted from theoretical efficiency, in calculating the net advantage of instrumentation, and the efficiency of the agricultural engineer in handling his job.

The agricultural engineer has occasion to use instruments to perform most of their common functions; to detect, identify, count, measure, trace, record, actuate, and control more accurately, positively, and economically than can be done by the human senses and manual skills with simple aids. He has occasion to make applications of relays, trigger mechanisms, and chain reactions. He has occasion to help agricultural scientists and farmers use them. He must be able to use them without becoming dominated by them and without allowing them to obscure his original objectives, or he will cease to be an agricultural engineer.

Agricultural engineers rarely if ever have instrument engineers available to take over all of their instrument problems. And when an instrument engineer is available for consultation, the agricultural engineering will find him most helpful if the agricultural engineer is well enough informed so that they can both think and talk the same language of advanced rather than elementary instrumentation.

Occasion for technical specialists to keep reasonably up to date on progress in related specialties is an old and growing problem. Some helps have been proven which can be applied to the agricultural engineers' problem of maintaining a practical working knowledge of instrumentation.

One such help would be increased contact between agricultural engineers and instrument engineers. It might be arranged quite easily.

Another would involve making existing knowledge of instrumentation more readily accessible to agricultural engineers. A good standard reference work or two on the principles, methods, and general types of equipment for instrumentation would help. A specialized compilation on instrument practice in agricultural engineering would be a further help. A complete job would require continuous condensing, digesting, indexing, cataloging, and publishing to make it easy for the agricultural engineer to find in the whole technical and trade literature of instrumentation the particular information he needs in connection with a particular problem.

Any progress that can be made in simplifying and making more effective our processes of sifting, recombining, and transmitting knowledge will be all to the good, in our world of increasing technical complexity.

Agricultural engineers' success in improving the equipment and methods of agriculture will be influenced to a large degree by their success in mastering, using, and improving the tools and methods of engineering. Increased attention to instrumentation is definitely in order.

Investment in Farm Production Facilities

PERSONAL considerations often influence farm investment in buildings and equipment. E. W. Lehmann (head, agricultural engineering department, University of Illinois) has called our attention to one specific case.

A group of economists, professional farm managers, and appraisers visited a farm and implied in their discussion that the farmer had invested too much in his buildings and equipment, from the economic standpoint of prospective return. That may have been true.

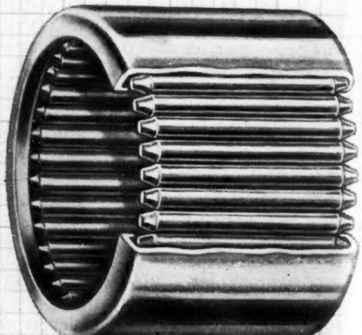
The farmer justified his investment in his dairy barn and equipment, one of the major items in question, "on the basis that it provided a good place in which to work, and he had found that his sons liked to work in the barn and that the same was true of his hired hands."

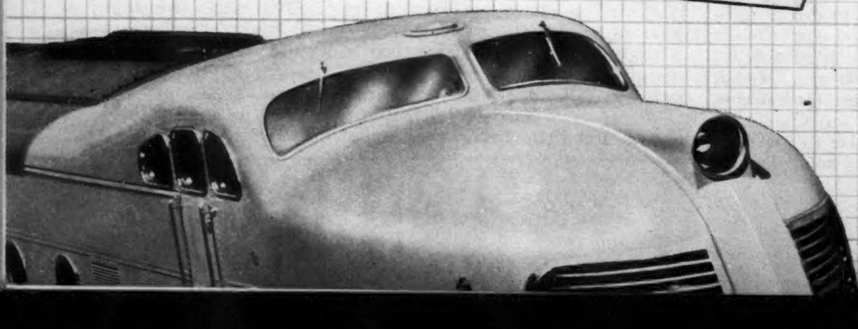
Actually the investment or overinvestment in question represented a use to which he had chosen to put some of the money he had made in farming. It was an investment of money he had made by practical application of knowledge in the professional field of his critics—economics, farm management, and appraisal of values. He had made enough more on his farm to buy another farm and some property in town.

Possibly this farmer's earnings might have been invested in better ways. Certainly they could have been invested or dissipated in many less desirable ways. The money which some farmers have invested in gold bricks might have gone a long way toward improving their living and working conditions, their old-age security, and their enjoyment of a full productive life, if invested on their own farms.

It occurs to us that different criteria must be applied to earned capital than to borrowed capital in justifying investment.

(Continued on page 302)





AGRICULTURAL ENGINEERING

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Development of a Dispenser for Applying Radioactive Phosphatic Fertilizer

By Glenn A. Cumings, Walter C. Hulburt and Dale B. Eldredge

Member A.S.A.E. Member A.S.A.E.

THE use of radioactive phosphorus in the tracer technique of studying the utilization of phosphatic fertilizers by crops under field conditions imposed new requirements on the dispensing and distributing equipment. Protection of the workers against harmful radiation and contact with airborne dust particles of the radioactive material was the paramount consideration.

Although special machines had been developed for uniform distribution, selected placements, and accurate control of application rates of ordinary fertilizers in field experiments, they lacked the protective features needed to insure safe handling of fertilizers containing radioactive phosphorus. The staff of the Fertilizer Distributing Machinery Project in the Division of Farm Machinery of the Bureau of Plant Industry, Soils and Agricultural Engineering was called upon late in 1947 to undertake the development of a suitable distributor for applying radioactive phosphate. This paper will be devoted primarily to the development of the dispensing unit.

The essential requirements of the radioactive phosphate distributor were first listed in conferences with representatives* of the division of soil management and irrigation of the Bureau, and of the North Carolina Agricultural Experiment Station. In addition to the usual requirements of the distributor for field research the following radioactive protective provisions were listed: (a) The hopper should be self-cleaning and completely emptied at the end of each run. (b) The workers must be shielded from the radioactive phosphate in the hopper by any material equal in weight to aluminum 1/6 inch thick. Lucite 6 mm (1/4 in) thick will stop completely beta-rays of P_{32} according to the National Bureau of Standards Handbook No. 42, "Safe Handling of Radioactive Isotopes." (c) There should be no rough or porous surfaces, pockets, ledges or obstructions where the phosphate may accumulate. (d) The hopper must be accessible for easy cleaning or decontamination. (e) Furrow openers must be designed to reduce to a minimum the possibilities of clogging. (f) Visibility through transparent shielding is essential at appropriate points to facilitate loading of the hopper and to readily detect any accumulations of radioactive phosphate in the system, including that resulting from a clogged furrow opener. (e) Adequate enclosure of the entire system is necessary to prevent the escape into the air of excessive amounts of radioactive fertilizer dust.

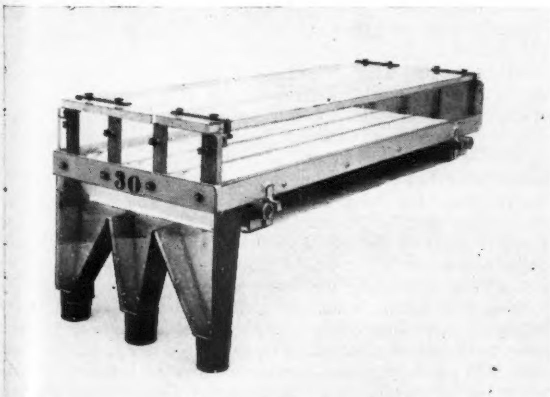
Of the numerous types of fertilizer-dispensing mechanisms covered by nearly 4,000 patents, two had been previously selected and quite extensively used for precise application of fertilizer in field research. One is the rotating-cylinder top-delivery type of hopper and the other is the endless-belt conveying and dispensing type. The endless belt was adopted mainly because it is self-cleaning and can be more easily enclosed and shielded.

Distributing machines have been manufactured for many years with a short endless belt at the bottom of a large hopper for continuously conveying the fertilizer through an opening the size of which is changed with an adjustable gate to vary the rate of application. For research purposes an endless belt of greater length is used in a different way. A predetermined amount of fertilizer for the area covered by a single passage of the machine across the plot is spread in a relatively thin

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The authors: GLENN A. CUMINGS, WALTER C. HULBURT, and DALE B. ELDREDGE, respectively, senior, associate, and assistant agricultural engineers, Division of Farm Machinery (BPISAE), U. S. Department of Agriculture, Beltsville, Md.

* Lyman A. Dean and Sterling B. Hendricks, division of soil management and irrigation; N. S. Hall, North Carolina Agricultural Experiment Station.



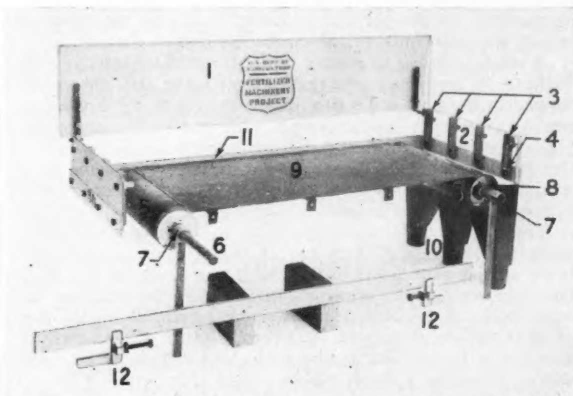


Fig. 1 (*Left*) USDA radioactive phosphate fertilizer hopper, endless-belt type with clear plastic side panels, partitions, lid and end • Fig. 2 (*Right*) The hopper from which the clear plastic panels and one lid section, the endless belt, and one side member of the frame have been removed. (1) Clear plastic lid in open position serves as a vertical shield. (2) Clear plastic end. (3) Channels in which side and partition panels are held. (4) Adjustable support for panel. (5) Pulley or roller. (6) Pulley shaft. (7) Bearing with slot into which frame fits. (8) Machine screw that fastens pulley to shaft. (9) Sheet-metal support for upper part of the belt. (10) Triple-tube delivery spout. (11) Projection of frame above the belt. (12) Pulley support bracket and adjusting screw with locknut

layer on the belt and is completely discharged during the prescribed operation.

J. P. Fairbank, agricultural engineering department, University of California, reported in 1940 and 1942 his use of the endless-belt principle in equipment for precise application of fertilizer on experimental plots(1,2)†. The distributing equipment was later designated as the "California End-feed Fertilizer Applicator." The hopper box travels forward with the belt and therefore must be returned to its starting position. A rotating brush uniformly sweeps a thin layer of fertilizer into the delivery tube.

A triple-feed unit of the California type of hopper was built by Rea and Meek(3) for mixing nitrogen, phosphate and potash in desired proportions as they were applied in the field. Various research men have assembled their own equipment and used the endless belt in a simple stationary hopper box without a dispensing brush. One implement manufacturer has equipped certain of his machines with the latter type of fertilizer hopper to aid research workers.

The design of the radioactive phosphate dispenser developed under the Federal Fertilizer Distributing Machinery Project at Beltsville, Md., is shown in Figs. 1 and 2. It consists essentially of a stationary enclosed hopper box with an endless-belt bottom. Longitudinal floating panels serve as the sides of the box and as partitions for dividing the hopper into two or more compartments. Spouts with dividers directly under the patition panels collect and channel the fertilizer into the delivery tubes. Hoppers of various dimensions have been built, but an over-all length of 36 in and widths to accommodate 8-in and 12-in belts are practical sizes which satisfy the needs in most cases for radioactive phosphate applications on relatively short plots.

DEPOSITING CALCULATED AMOUNT OF FERTILIZER

As indicated earlier the calculated amount of fertilizer to be applied during each run of the machine over a single row or plot is deposited on the belt and confined to a section of a length predetermined to insure complete application on the plot. In a hopper 36 in long, with three compartments on a 12-in belt, the horizontal section of the belt on which the fertilizer can be deposited in each compartment is 3 in wide and 26 in long. Drive sprockets can be mathematically selected to move the belt approximately the desired distance for a particular length of plot. The movement of the belt or length of the section to receive the fertilizer can then be exactly determined by operating the machine from one end of the plot to the other. Inasmuch as the strip of fertilizer on the plot is merely an elongation of the band of fertilizer on the belt, it is essential that the fertilizer be accurately and uniformly distributed on the belt. Special devices have been developed to facilitate the transfer of the radioactive phosphate from its container to the hopper and to aid in spreading the material readily and uniformly on the marked section of the belt.

A rotating brush to control the fertilizer mechanically and discharge it uniformly into the delivery tubes was not incorporated in the hopper because of the danger of the brush becoming excessively contaminated with radioactive material. Also, complete enclosure of the hopper is simplified when a brush is not installed. A free-flowing fertilizer deposited in a relatively shallow layer on the belt will be dispensed uniformly without the aid of a brush.

The amount of fertilizer containing radioactive phosphorus needed for a single plot or run of the machine is relatively small, so the material is usually in a thin layer on the belt. The maximum depth at which material on the belt can be satisfactorily distributed depends upon the drillability of the fertilizer and other factors, but when a depth of one inch is exceeded, irregular distribution and other complications may become particularly objectionable.

The belt operates over brass pulleys 3 in in diameter. The drive pulley has a knurled surface which helps to prevent slippage of the belt. A wooden pulley was also successfully used. A pulley 1 in in diameter for the delivery end of the belt has proved satisfactory, but of no significant advantage over the 3-in pulley with regard to delivery of the fertilizer. The 3-in pulleys are identical in their design and mounting, so they can be interchanged and each pulley can be turned end for end. It is therefore possible to place the drive sprocket in any one of the four corner positions.

The pulleys are held in place by brackets welded to the frame. Each bearing rests against the adjusting bolt, and it is held in position on the shaft by a groove into which the frame fits. The pulley can be taken out of the frame by first removing the shaft, which is fastened to the pulley with a machine screw. Both pulleys have adjustments on each of their bearings to maintain proper tension and alignment of the belt.

The upper portion of the belt is supported by a sheet of metal to eliminate sagging, thus insuring that the hopper panels rest evenly on the belt. The support also serves as a barrier against radiation. To remove or install an endless belt it is necessary to remove the sheet metal support as well as the pulleys.

A belt with a smooth dense surface is required to avoid adherence of the radioactive material. Rubber food-conveyor belting approximately 1/8 in thick was first selected and found satisfactory. The rubber belting was spliced endless with metal lacings for the initial hopper. Splicing by overlapping and vulcanizing the ends of the belt was also tried. In both cases the splice was appreciably thicker than the belt. It was therefore necessary to return the splice to a particular starting point before each run in order to prevent it from passing under and unduly raising the panels during the operation of the machine. A rubber belt made endless in the manufacturing process and therefore of uniform thickness throughout apparently can be obtained. A relatively inexpensive woven cotton belt stitched endless and coated with cellulose was later adopted after it was found satisfactory by J. G. Futral of the Georgia experiment station.

A clear acrylic plastic (specific gravity, 1.19) 1/2 in thick is used for the panels, lid and delivery end of the hopper to permit visibility as well as to protect the worker against harmful radiation. The acrylic type of plastic (either Plexiglas or Lucite) can be shaped with woodworking tools. Sheet-metal screws were found satisfactory for joining one piece to another. A thickness of 1/2 in is needed for sufficient rigidity of the plastic sheets. For more complete protection the sides of the frame extend above the belt to stop any rays that may pass between the panels and the belt.

PROVISIONS TO GUARD AGAINST UNDUE WEAR

The side panels and partitions, 3 in in height, rest on the belt and are free to move upward in the channels at the ends. The phosphate, which contains sand as a conditioner, if allowed to accumulate on the lower edge of the panel, will wear the belt by abrasion. To guard against extreme wear the panels are prevented from moving downward by an adjustable support at each end. A groove is cut longitudinally in the bottom edge of each panel for two reasons: (a) The surface in contact with the belt is thereby reduced to a narrow strip 1/16 in wide at each side, which minimizes the possibility of fertilizer adhering to and accumulating on the edge of the panel. (b) The insignificant amount of fertilizer that may be forced under the panel will remain in the space provided by the groove and be discharged into the delivery tubes. The abrasive wear of the belt under the panels involves negligible depreciation cost but it can be minimized in two ways: (a) by periodically inspecting the lower edge of the panels and removing any accumulations of fertilizer material and (b) By keeping the fertilizer away from the panels, which can be done with small lots of material. The belt projects 1/2 inch beyond each side panel to guard against any loss of fertilizer and to allow for lateral movement required for alignment of the belt as permitted by a 1/4-in clearance of the belt within the frame.

The hopper lids are hinged in such a way that they remain in an approximately upright position when opened and also slightly overlap the side panel to form a complete shield against radiation. This arrangement provides adequate protection as well as visibility for the operator while he is loading

† Numbers in parentheses refer to the appended references.

the hopper. The lid on an 8-in belt hopper is in a single piece while that on a 12-in belt hopper is divided into two parts. The single lid can be shifted from one side of the hopper to the other side in case prevailing winds are a consideration.

The plastic end of the hopper also serves as the face of the fertilizer delivery spouts. It permits visibility for observing the flow of fertilizer and detecting any accumulations of material in the spouts.

Delivery tubes must be made of material which will prevent the escape of dust and in most instances they must be flexible. Spiral steel ribbon tubes covered with a suitable plastic or cloth sleeve and pliable plastic tubing have been used.

Satisfactory furrow openers of either disk or shovel types with a well-enclosed channel for conducting the fertilizer into the furrow are needed and are on the market. Some provision for readily observing or detecting a clogged furrow opener or the accumulation of fertilizer in the delivery tube is desirable. It is most important, however, to use preventive measures by exercising due precautions in the installation of the delivery tubes to avoid sharp bends or collapsed sections, and by carefully operating the machine to avoid sudden lowering of the furrow openers into the soil, rearward movement, and other causes of furrow-opener clogging.

Single as well as multiple-compartment hoppers have been built, the basic difference being in the width of the hopper. The practical limits of belt width and number of compartments will vary according to the circumstances. The 3-compartment hopper with a belt 12-in wide is a versatile unit of reasonable dimensions and weight that can be used in various ways as follows: Without any mechanical changes the fertilizer can be discharged in separately controlled amounts through one, two, or three tubes by loading only the corresponding compartments. Therefore, the fertilizer can be conducted through separate tubes to one, two, or three closely spaced crop rows, or it can be deposited in one, two, or three bands along a single crop row. Also, a different material can be applied through each of the tubes.

Other uses of the hopper are possible by changing the delivery spout and rearranging the partition panels. Nitrogen, phosphorus, and potash materials, if put into separate compartments, can be brought together in a common spout (provided for the purpose) and the amounts of each material can be varied to produce desired ratios in the mixtures. Either one or both of the partition panels can be lifted out of their channels to form a compartment of double or triple width. By relocating the channels, the partitions can be shifted to vary the width of compartments.

The radioactive phosphate hopper can be used satisfactorily to dispense ordinary fertilizers and other materials in good drilling condition. Practical dimensions of hoppers will impose certain limitations on the quantity of fertilizer that can be applied in a single operation, which in turn will place limits on the rate of application or size of plot or both.

The initial hopper was mounted on a light pull-type chassis for general use. The hoppers can be mounted on tractors or on practically any of the larger implements. The kind and size of machine required, the soil-working equipment, the number of fertilizer conductor tubes and other mechanical features are determined by the plan and specifications of each experiment.

Adaptation of the hopper to meet new requirements and the development of suitable implements for different kinds of radioactive phosphate experiments with various crops are in progress jointly by the BPISAE and several state agricultural experiment stations‡.

AUTHORS' NOTE: Among the cooperating experiment station workers who are giving attention directly to the design and construction of the special radioactive phosphate machinery are the following: E. N. Scarborough, and R. W. Wilson, agricultural engineering department, North Carolina Agricultural Experiment Station; J. G. Futral, agronomy department, Georgia Agricultural Experiment Station; H. E. Rea, agronomy department, and H. P. Smith, agricultural engineering department, Texas Agricultural Experiment Station; D. M. Kinch, agricultural engineering department, Indiana Agricultural Experiment Station; H. M. Gitlin, agricultural engineering department, Ohio Agricultural Experiment Station; L. H. Hodges, agricultural engineering department, Wisconsin Agricultural Experiment Station, and E. V. Collins, agricultural engineering department, Iowa Agricultural Experiment Station.

‡ The radioactive phospate hopper described in this report, for purposes of identification, has been designated as the "USDA Radioactive Phosphate Fertilizer Hopper".

REFERENCES

1 Fairbank, J. P.: Experimental Machines for Fertilizer Placement. Proceedings of the National Joint Committee on Fertilizer Application 16:62-78 (1940).

2 Fairbank, J. P. and Minges, P. A.: An Accurate Fertilizer Applicator for Field Test Plots. Proceedings of the American Society for Horticultural Science 41:310-314 (1942).

3 Rea, H. E. and Meek, W. E.: A Two-Row Tractor-Mounted Multiple Fertilizer Distributor for Row-Crop Field Tests. Unpublished.

Professional Registration of Agricultural Engineers

By J. W. Martin

ASAE members are becoming aware of the importance of professional registration. Since July, 1947, the total number of registered engineers in the Society has increased from 194 to 320. The number in the agricultural engineering classification has increased from 56 to 115. The information for the following tabulations was obtained from a summary of the cards returned for the latest ASAE membership directory.

Table 1 shows the total number of ASAE members registered as professional engineers. There are 282 living within the United States, and 38 living outside. At the time the cards were submitted 9 men were classed as engineers-in-training awaiting the time until they could fulfill the experience requirement for registration. In addition nine had made application for registration.

TABLE 1. ASAE MEMBERS REGISTERED AS PROFESSIONAL ENGINEERS AS OF AUGUST 31, 1949

Members registered as engineers living within the U. S.	282
Members registered as engineers living outside the U. S.	38
Members as engineer-in-training	9
Members with application for registration	9
Total number of ASAE members registered in all branches of engineering	338

Some states do not have the classification of engineer-in-training. However, the National Council of State Boards of Engineering Examiners has a committee report on this subject in their quarterly bulletin of December 1949. The major objectives of the engineer-in-training program may be stated as follows:

"1 To make the young engineer more conscious of his obligation as a member of the engineering profession and to acquaint him with the procedure, requirements and advantages of registration

2 To permit him to take the first step towards registration by passing a written examination on theory while the subject matter is fresh in his mind.

3 To assist the young engineer in obtaining immediate professional affiliation, guidance, and protection.

4 Through increased professional consciousness, better knowledge of the registration procedures, and reduced fear of the final examination, to encourage the young engineer to acquire professional status by registration as soon as he is legally qualified.

Table 2 compares the number of ASAE members living within the United States on July 30, 1949, who were registered engineers in all branches of engineering with the number of members who were registered engineers on August 31, 1949. The table shows further the number of registered engineers who were classified as agricultural engineers on both of these dates. California has the largest number of ASAE members (36) who are registered engineers in all branches, and Illinois is second with 28. Iowa leads in the

This is a progress report from the ASAE Committee on Professional Registration, J. W. Martin, chairman.

number of registered agricultural engineers with 13, and Texas is second with 12. That agricultural engineers are just entering this important phase of professional activity is shown by the fact that on June 30, 1948, there were 126,350 registered engineers.

TABLE 2. COMPARISON OF ASAE MEMBERS REGISTERED AS ENGINEERS

Date	Number in all branches of engineering	Number in agricultural engineering classification
July 30, 1947	193	56
August 31, 1949	282	115

Table 3 shows the branches in which the members are registered. There are 115 members registered as agricultural engineers. If they were registered in other branches also, the second registration was not counted. Many engineers are registered in two or more branches. There are 52 members registered as civil engineers and 46 as mechanical engineers.

TABLE 3. ASAE MEMBERS REGISTERED AS PROFESSIONAL ENGINEERS AND LIVING IN THE U. S. AUGUST 31, 1949

Agricultural engineers	115
Civil engineers	52
Mechanical engineers	46
Electrical engineers	17
Architectural and structural	19
No branch indicated	16
Miscellaneous	17
Total	282

No information was available as to the date of each member's registration. However, date of his membership in ASAE was obtained. Of the members living in the United States, 19 who joined ASAE before 1920 were registered engineers, as compared with 81 registered engineers who have become members since 1945. This information indicates that there are a large number of eminently qualified ASAE members not yet registered. Of the 34 registered engineers living outside the United States who have become ASAE members since 1931, 23, or 68 per cent, have joined the Society since 1945. The number of registered engineers joining the Society has increased each succeeding 5-year period since 1931 except during the depression years of 1931-35 and the war years of 1941-45.

Engineering Colleges and Industry

IN THIS day and age of adjustment of some of our fundamental concepts we realize that progress in science and technology is far ahead of that which has been made in our economic, social, and human relations. One thing learned, and probably through bitter experience in the past three years, is that we are no longer individualists or isolationists. At best, we are component parts in the developments of our community, nation, and world. If we are to make gains, plans must be made on an industrial and community basis dealing with this problem of educating young men for industry. The only proper approach is for the educators and the industrialists to join hands to develop a program for the best engineering training possible. Further, we must have full opportunity and mutual support for a continuous, cooperative training program for engineering teachers, whereby they will be briefed and will have opportunity through personal experience to learn new and modern engineering design, processes, and economic development.

To aid such a correlation between engineering education and industry, the American Society for Engineering Education must reach and interest all industries both large and small. I believe that the Society has its greatest challenge and its best opportunity to serve the future young engineers by expanding its work with small industries. There must be developed a mutual understanding as to the contributions that can be made by proper engineering in industry, government, the development of state highways, and in the field of sanitary engineering. The southeastern region of the United States has made much progress in this direction but much more must be done. —J. H. Lampe, in the *Journal of Engineering Education* for March, 1950.

Agricultural Processing

A Message to ASAE Members:

FARM products processing as an agricultural engineering activity is becoming more extensive and important as time progresses. The upswing in importance has been especially marked since the war by added impetus of such activities as farm products drying, including cotton, processing of fiber crops, improvement of dairy processing techniques, development of rural industries, processing fruits and vegetables, improving the use of labor—to mention a few.

Since there is considerable important activity in this area under various and sundry divisions and other activities of ASAE, some integration appears to be advisable.

Therefore, the Committee on Agricultural Processing submits the following for consideration in order to expedite the activities within the area:

I. Webster defines the word "process" thus: "to subject (especially raw material) to a process of manufacture, development, preparation for the market, etc.; to convert into marketable form, as livestock by slaughtering, milk by pasteurizing, grain by milling, cotton by spinning, fruits and vegetables by sorting and repacking . . . . . ."

In light of this definition and the current processing activity within the Society, the Committee proposes that agricultural processing be considered to include any processing activity which is or can be done on the farm or by local enterprises in which the farmer has an active interest. More specifically any farm or local activity which maintains or raises the quality or changes the form or characteristics of a farm product may be considered as processing.

For example, some activities which fall in this classification follow; others not listed are probably characteristic of local regions:

Seed and grain processing by cleaning, sorting, grading, treating, drying

Hay processing by chopping, grinding, drying, and dehydrating

Feed grinding and mixing (farm and commercial)

Rice drying and milling

Cotton drying and ginning

Tobacco curing

Fiber separation

Fruit and vegetable packing, canning, drying, dehydrating, freezing, storing

Dairy products handling and manufacture

Poultry products processing

Meat processing, slaughtering, handling, curing, freezing

Sorghum and molasses making

Treating fence posts and timber products

Manufacture of crop-residue wallboard.

Acceptance of boundaries for the "processing" area will aid in developing the work, particularly that of training for engineering activity in it. Note that as considered the engineer must be versed in such advanced techniques as fluid mechanics, including pumps and fans, heat transfer, refrigeration, drying, air conditioning, sorting, size reduction, materials handling, work simplification, plant layout, etc.

II. Current process engineering activity is taking place in the various divisions of our Society and in many colleges and universities in departments other than engineering. In view of this diversification a survey somewhat comparable to those made by Walker and Giese in the machinery and structures fields, respectively, (USDA Miscellaneous Publications 38 [1928] and 133 [1932] is proposed.)

The results of such a survey would provide a complete list of activities in the area which need development or research.

Your Committee solicits comments, suggestions and criticisms of our proposals and would specially welcome offers of members to help with the work.

S. M. HENDERSON
Chairman, ASAE Committee on Agricultural Processing

(EDITOR'S NOTE: Response to Mr. Henderson's solicitation may be sent direct to his address: Agricultural Engineering Bldg., College of Agriculture, Davis, Calif.)

Aerodynamics of Wind Erosion

By A. W. Zingg and W. S. Chepil
MEMBER A.S.A.E.

THE dynamic action of fluids on the land surface takes many forms. While all of them are in some measure geological processes, they may assume economic importance through, or to, the activities of man.

The problems may be the accelerated downslope movement of soil by surface runoff or rainfall impact on cultivated lands. It may consist of the beating of wind-formed waves eroding the materials along a highly developed shore line. Again, it may be the distribution of drifting snow affecting the snowmelt from mountainous areas or the distribution of moisture in prairie regions. It may be the rolling of sediment along the beds of streams and rivers. Finally, exposed soils may be moved bodily by the action of the wind.

Basically, all of these phenomena present related research problems: namely, (a) the determination of the incidence and nature of a fluid force near the interfaces of fluid and solid media, and (b) the determination of the properties of the material in question to resist the fluid force. Methods of control must strive (a) to modify the force on the material susceptible to movement or transportation by the fluid or (b) to modify the material either to increase or to decrease its detachability.

As early as 1911, Free(5)* published a bibliography of aeolian geography. It contains 2,475 references having to do with phenomena related to wind and soil formation, transportation, detachment, etc. It is interesting to note that approximately 75 per cent of the articles listed are of foreign origin. Again, in 1941, Malina(11) published a review paper, entitled "Recent Development in the Dynamics of Wind Erosion." This paper contains 59 references and is an excellent summary of developments to that date.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Soil and Water Division. It is also authorized as Contribution No. 403 from the department of agronomy, Kansas Agricultural Experiment Station, and the Soil Conservation Service, U. S. Department of Agriculture and is based on cooperative investigations in the mechanics of wind erosion.

The authors: A. W. ZINGG and W. S. CHEPIL, respectively, project supervisor (research), Soil Conservation Service, USDA, and professor of soils, Kansas State College, Manhattan.

AUTHOR'S NOTE: Grateful acknowledgment is made to E. A. Engdohl, agricultural engineer, formerly attached to the project, for his contribution to the work reported in this paper.

* Numbers in parentheses refer to the appended references.

Due to limited funds and the large turnover of research personnel during the war years, fundamental research on the problem was at a low ebb in the United States. Gone also was the combination of drought, high winds, and general economic distress which spotlighted the problems of the plains area in the thirties.

The following statements can be made regarding our approaches to the wind erosion problem in general:

1 Progress has been made in developing controls, more or less by trial-and-error methods in the field. We do not have, however, the basic information on the relationship between wind, soil, vegetative cover, and topography that is necessary to design preventive measures.

2 At the present time, we must look chiefly to the works of investigators in other countries or to studies in allied fields of endeavor for a body of fundamental information bearing on the subject.

3 The problem of soil movement by wind in the United States is undoubtedly of less over-all economic importance than that of soil erosion by intense rainfall. Perhaps for this reason, research on the problem has received little attention.

Professor James C. Malin(10), historian of the University of Kansas, has stated: ". . . both the relative frequency and severity of the dust storms were grossly misrepresented during the drought period of the 1930's and the public and scientific world are badly informed about the whole subject."

The High Plains Wind Erosion Laboratory. A study of the mechanics of wind erosion was initiated at Kansas State College, Manhattan, in the late fall of 1947. Research on the problem deals with the fundamentals of the movement of soil by wind in the high plains area. Administratively the project is a cooperative one between the Kansas Agricultural Experiment Station and the research division of the Soil Conservation Service. Work is centered in the Department of Agronomy of the Kansas station. Studies are regional in character.

Objectives of the research are as follows:

1 To determine the causative factors of wind erosion, and the processes by which soil materials are moved and transported by wind.

2 To develop suitable methods for studying the phenomenon of wind erosion.

3 To determine the effects of physical and chemical soil properties, such as structure, texture, kind and amount of

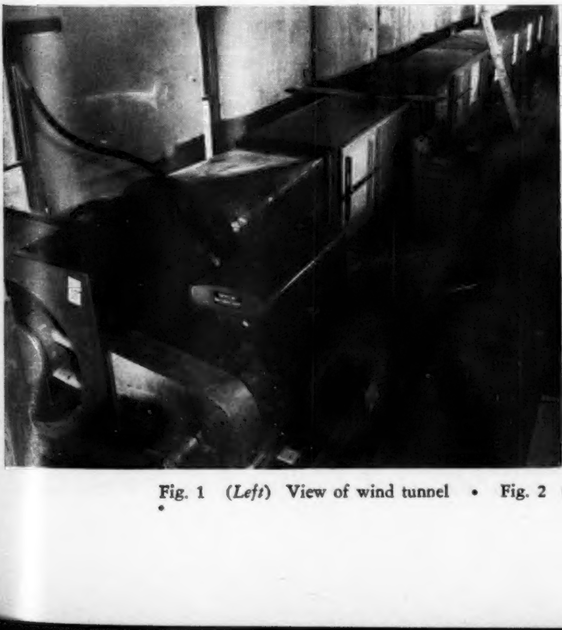


Fig. 1 (*Left*) View of wind tunnel • Fig. 2 (*Right*) Equipment used for velocity determinations

organic matter, lime, and alkali salts content, and possibly other soil charactertistics on the detachability of soil by wind.

4 To evaluate the effects of plant covers and residues, surface barriers, various topographic features, the degree and nature of the surface roughness, and various mechanical and land-use practices on soil drifting.

5 To delineate principles upon which the design of control practices can be based.

The first year was devoted primarily to development. By the end of 1948, a laboratory and a field wind tunnel had been constructed and subjected to preliminary tests. A laboratory for carrying out certain physico-chemical analyses of soils subject to wind erosion was also equipped. Studies of the physical and chemical properties of soils as related to wind erodibility have already yielded valuable information.

The Soil-Blowing Tunnel. The consensus of those who have worked with wind erosion investigations is that most problems of a fundamental nature may best be studied with an artificial air stream since variables common to the problem may be better controlled in a wind tunnel than in the open. Tunnels of various types and sizes have been devised by workers in this field. Bagnold(1) of England studied the physics of wind-blown sands and desert dunes with a suction-type laboratory tunnel having a 1-ft square cross section and a length of 30 ft. Chepil(13) of Canada employed a circulating-type laboratory tunnel having a rectangular working section 2½ ft in width by 2 ft in height and a length of 13 ft; also a portable field tunnel with a cross section 3 ft wide and 3½ ft high, wherein the length was varied from 32 to 48 ft. Malina(11) of California developed a laboratory tunnel of the suction type with a working section 2½ ft wide by 1½ ft in depth. Its length was 12 ft. Again, a portable tunnel for field use was constructed by Joy(6) in South Dakota. The dimensions of the tunnel were 3½ ft wide by 3 ft in height by 48 ft long. Schoenleber(12) of Kansas constructed and made preliminary tests on a field tunnel with a square section of 4 ft and a length of 39.4 ft. More recently, Kucinski(9) of Massachusetts constructed a laboratory tunnel 3 ft square with a working section 16 ft long.

From the above, it is apparent that the type and dimensions of the wind tunnels used to study erosion have varied greatly. Unavailable for all tunnels is a comprehensive description of the characteristics of the air stream throughout the length of the working section. In general, the laboratory-type tunnels have been of the suction or circulating type. Those designed for use in the field have employed a propeller to force the air stream through the duct. Only very elementary straightening vanes have been used on the latter and their aerodynamic characteristics are largely unknown.

In developing the present wind tunnel at Kansas State College the plan has been to construct one of a type and dimension suitable for use either in the laboratory or in the field. Flexibility which will permit optional conversion between the forced air, suction, or circulating types has been maintained. Thus, in effect, the field-type tunnel has been brought into the laboratory for development. The cross section of the present duct is 3 ft square, and its length is 56 ft. The building which houses the tunnel is 92 ft long.

A photograph of the tunnel and air-moving equipment is shown in Fig. 1. The wind-making equipment is comprised of a governor-controlled gasoline engine and a heavy-duty axial-type ventilating fan. Both are assembled as a portable trailer unit. Control of air movement is effected partly by changing the speed of the engine and also by an adjustable-vane inlet not shown in the photograph. For normal operating ranges the engine is run at a constant speed and control is obtained with the adjustable air-intake device. The air flow from the fan blades is redistributed and evened out by a series of screens in the metal transition section connecting the fan to the duct. A honeycomb-type air straightener is located in the upper portion of the duct immediately below this transition section. It is fabricated from 324 two-inch aluminum tubes, each 1 ft in length.

The 56-ft length of the tunnel was made by joining together seven separate sections, each 8 ft in length. The sides of the duct are comprised of alternate plywood and plate glass panels. The alternate wooden panels are removable to give easy access to the test space. Removable also is the top of the duct which is made from ¾-in plywood. In addition, the top panels slide along the horizontal length of the duct to provide ingress for air measuring and other devices at desired points. Air flowing from the end of the tunnel discharges into a dust-collecting room, with a floor area of 300 sq ft and a height of 13 ft. It is then discharged outside through doors or through ports in the ceiling to the second floor of the building, where it may be recirculated to the fan. In the arrangement shown in Fig. 1, the air-moving unit pushes the wind stream through the tunnel. By placing this unit in the room beyond the far end of the duct, a suction-type tunnel is obtained.

Soil trays of a 18-in width are to be installed in the center of the 3-ft tunnel width. During operation, changes in soil weight throughout the length will be recorded on scales below. To be installed also are scales to determine the shearing or tractive force of the air stream on the soil surface.

An aluminum duct will be used with the portable air-moving unit in the field. It is comprised of collapsible sections 6 ft in length. Should the arrangement prove practical, it will be used to determine drifting characteristics of soils in their natural state.

A six-tube multiple manometer has been constructed for use in determining velocities of air movement in the tunnel or in the field. The slope of the tubes magnifies changes in liquid elevation 20 times. Alcohol is used to give the sensitivity desired. A movable staff holding 6 pitot tubes is used to make velocity traverses throughout the tunnel. A close-up view of the apparatus is given in Fig. 2.

A typical distribution of air flow common to the tunnel is shown in Fig. 3(A). Plotted isovels are those for a cross

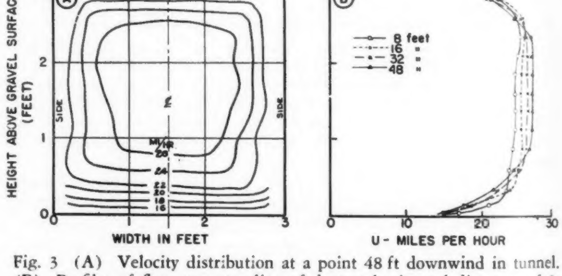


Fig. 3 (A) Velocity distribution at a point 48 ft downwind in tunnel. (B) Profiles of flow at center line of duct at horizontal distances of 8, 16, 32 and 48 ft downwind in tunnel

section located 48 ft to leeward of the honeycomb straightener. In this instance the floor was covered with non-erosive gravel ranging in diameter from ⅛ to ¼ in. To obtain the favorable distribution of the air stream shown, it was necessary to even out irregular delivery characteristics of the fan with a series of screens. The utilization of a precisely made straightening device to remove both vertical and horizontal components of rotational flow was also essential. Incidentally, approximately one-third of the fan velocity pressure was sacrificed to accomplish this end. It is apparent that a suction-type tunnel would be more efficient. Problems connected with pulling eroded materials through the fan may, however, offset this advantage.

Profiles of air flow along the vertical center line of the tunnel are given in Fig. 3(B). Points of inflection in the curves indicate that the turbulent boundary layer attains a height of approximately 2 in above the gravel surface in a distance of 8 ft. It develops progressively to a height of 10½ in at a location 48 ft down the duct. Growth of the boundary layer is proportional to the four-fifths power of the tunnel length. To satisfy the law of continuity, the flow in the central portions of the tunnel must therefore, increase in the uniform cross section used. It is believed that all the duct, excepting possibly the first 16 ft, has conditions of air flow suitable for test purposes. Extrapolation of the length-

boundary layer growth relationship indicates that a duct length in excess of 100 ft would be required for the boundary layer to develop throughout the central regions of the tunnel.

Description of Wind Movement. Atmospheric surface winds are turbulent for all velocities in excess of approximately 2 mph. Turbulence of the wind in the open is indicated by the irregular velocity fluctuations known as gusts. Technically, the wind movement in which we are interested from a soil erosion standpoint may be described as a turbulent boundary layer above an aerodynamically rough surface.

A "rough" surface is one in which separation of the flow occurs from the macroroughness of which it is comprised. The low intensity of the pressure in the wake of the roughness leads to resultant forces which oppose the motion. Such forces are customarily termed "form drag."

An expression to describe fluid flow of this type in round pipes has been developed by von Karman(8) as follows:

$$\frac{\mu}{\sqrt{\frac{\tau}{\rho}}} = \frac{1}{K_0} \, ln \, \frac{z}{K} + C \quad \text{[1]}$$

where μ = the average velocity of the fluid at a distance z normal to a pipe wall; the expression $\sqrt{\frac{\tau}{\rho}}$ is termed the friction velocity, where τ is the intensity of the shearing force per unit area at the pipe wall, and ρ is the density of the fluid; K_0 is a dimensionless constant usually associated with a characteristic turbulent mixing length; K is the linear height of the surface roughness, and C is a constant. Prandtl(2) has suggested that equation [1] could be extended to the atmosphere.

Comprehensive experiments in round pipes were carried out by Nikuradse(14) to determine the constants for equation [1]. This was accomplished by cementing sand grains of various sizes to the pipe wall. A value of $K_0 = 0.4$ and of $C = 8.5$ was found to satisfy the relationship. Substituting these values of K_0 and C in equation [1] and converting to the logarithmic base 10 yields the expression

$$\frac{\mu}{\sqrt{\frac{\tau}{\rho}}} = 5.75 \log. \frac{z}{K} + 8.5$$

A value of $K/30$, designated as k, will satisfy the above expression and eliminate the constant $C = 8.5$, which after transposition becomes

$$\mu = 5.75 \sqrt{\frac{\tau}{\rho}} \log \frac{z}{k} \quad \text{[2]}$$

This basic equation with several modifications has been used by Bagnold to describe the variables common to sand movement by wind both in the wind tunnel and the open field. Chepil has likewise applied it to an analysis of soil drifting by wind.

Application of equation [2] has proved a very useful tool in clarifying the wind erosion phenomenon. The relationship has, however, been developed for pipes in which the linear dimension of the roughness has been superimposed on the pipe wall. The base for measurement of z was a specific surface which does not exist for surfaces in the field. Further, the value of K is a linear dimension of roughness only. Land surfaces in the field have roughness varying in height, spacing, porosity, angularity, etc. Because of these differences, difficulty is encountered in applying the expression. An illustration of such experience will be given.

A series of wind velocity measurements was made over a cultivated stubble on the Agronomy Farm near Manhattan on October 15, 1948. Irregularties of the surface varied from 3 to 6 in vertically. Velocity measurements of the atmospheric wind were obtained simultaneously at each of 5 elevations. Pitot tubes and a multiple manometer were used for this purpose. Fifty sets of readings were obtained at approximate 10-sec intervals.

To fit the data obtained into equation [2], it was necessary to orient the elevations at which readings were secured to a height comparable to the z defined therein. The average velocity should plot as a function of the logarithm of z when this is accomplished. The steps followed in doing this were as follows:

1 Leveling of the irregularities of the surface, above which readings were taken, to determine its average elevation.

2 Determining by trial and error the adjustment required from the average elevation of the surface to make the semi-logarithmic plot project as a straight line to an average zero velocity at a finite height (k).

In this particular instance it was found that the height z must be measured from an elevation 1½ in below the average elevation of the surface to produce the desired velocity-log height relationship. A plot of the individual velocity readings obtained at heights determined by the above orientation is shown in Fig. 4(A). A line representing the average of the readings is presented in Fig. 4(B). It will be noted that the

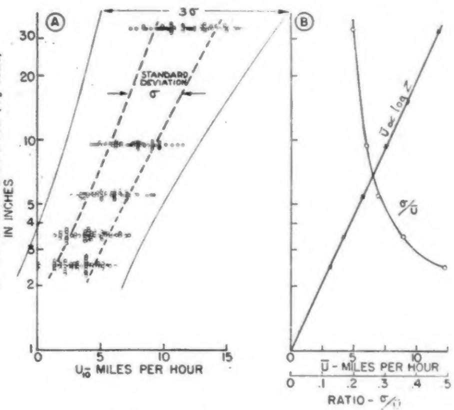


Fig. 4 (A) Values of wind velocity at various heights secured at 10-sec intervals in the open over a rough cultivated stubble. (B) Showing relationship obtained for an average of the velocities at each height, also the ratio of the standard deviation to the average velocity at each height

value of k, or the height at which an average zero velocity, is, in this instance, one inch above the datum for measurement of z. If the value, $k = 1$ in, is interpreted in the light of its meaning according to the equations and experiments from which it was derived, the linear height of roughness is found to be equivalent to 30 in. This is not reasonable. In other words, the state of the surface and velocity distribution over it apparently vary widely from the original experiments in pipes.

The above difficulties and uncertainties involved in applying equation [2] have been encountered likewise in preliminary experiments with surfaces of varying roughness in the laboratory tunnel. At present, efforts are being made to develop basic formulas which may be applied more easily. Attempts are also being made to derive a parameter to define better the aerodynamic roughness of various land surfaces.

In investigations of sediment transportation a clarification of factors governing bed-load movement recently has been obtained. This has been accomplished by considering the value of velocity fluctuations and associated forces in initiating movement of particles. These principles have not been applied to the initiation of movement of soil by wind; however, the approach as outlined by Kalinske(7) appears to offer possibilities. The range of the standard deviation, σ, of the velocity measurements presented is given in Fig. 4(A). Shown also is the value of 3σ or the limit of 99.7 per cent of the occurrences, provided the velocity fluctuations follow the normal error law. In this instance, it is to be noted that the average velocity at a 2½-in height (near the maximum projections of the surface) is approximately 3 mph. The limit of 3σ is 7½ mph. Assuming that the shear on particles at this point on the surface is proportional to the square of the velocity, the tractive force for maximum velocity fluctuations would be over 5 times the value common to the average velocity.

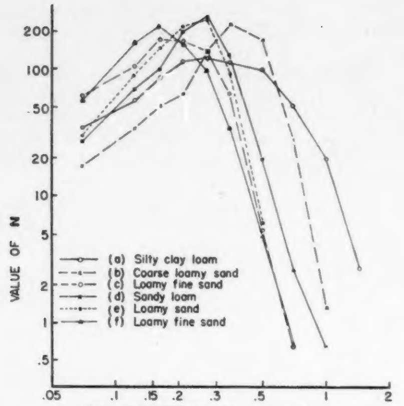


Fig. 5 Size distribution of soil grains found in newly formed drifts in the spring of 1948

The ratio of the standard deviation to the average velocity, σ/U, is plotted for various heights in Fig. 4(B). This factor is associated with the relative intensity of gusts. Thorough investigation of the value of this ratio should be made for wind movement in the field. A common statement encountered in the plains is "Some winds move soil while others that blow just as hard do not." The relative magnitude of gusts could well have a bearing on the subject.

Movement of Soil by Wind. The movement of soil by wind is a complex process influenced by innumerable conditions of wind, soil, and nature of the eroding surface. The effects of some of these conditions have been studied by various investigators. Much more information will be necessary, however, before the wind erosion process can be understood and described thoroughly. Likewise, more information is needed to evaluate the effects of various cultural treatments and control practices on the drifting of soil by wind.

The soil is moved by wind in three types of movement—saltation, suspension, and surface creep. Accurate measurement of each type of movement, particularly of suspension, is difficult. Attention is being given at present to devising more accurate methods of measurement than have been used formerly.

In addition to the variations in the types of soil movement, the wind erosion phenomenon is further complicated by close interdependence of at least five forms of erosion. Chepil(3) has recognized these forms, although all can well be considered as different phases of the same phenomenon. These forms described are effluxion, extrusion, detrusion, efflation, and abrasion. Some, or all, of these forms may be operating at the same time. However, none of the forms can exist without effluxion, which consists primarily of the removal by wind pressure of the grains moving in saltation. Effluxion is, in other words, a prerequisite to, and a cause of, the other forms of erosion. This form of erosion involves the movement of a relatively narrow size range of soil particles, usually within 0.05 to 0.5 mm in diameter. The whole program of wind erosion prevention and control should, therefore, be based on either reducing the amount of this size of particle in a soil to an allowable minimum, or protecting it from the erosive force of the wind. Investigations are being conducted to determine this minimum for various soil types, surfaces, and wind velocities. Experiments have also been undertaken to find out how best to alter the size of soil aggregates so they will offer the greatest resistance to erosion by wind and, at the same time, preserve a favorable condition for growth of crops.

Investigations are being made of the intricate phenomenon of the sorting of soil material by the wind and its relationship to possible changes in the productivity of agricultural land. Fig. 5 gives some information on the size distribution of soil material blown about and deposited by wind to form drifts or small dunes on several soils in Kansas in May, 1948. The grading patterns shown in this figure were obtained by plotting the logarithm of the percentage weight of soil per unit of the log-diameter scale against the logarithm of grain diameter. Assuming the diameter limits of each fraction as determined by sieving to be d_1 and d_2, the logarithmic interval of grain diameter is given by $\log d_1/d_2$. The percentage weight P of each grade per unit of log-diameter scale is then equal to ΔP divided by $\Delta \log d_1/d_2$, which is designated by N. For a given soil material, it will be seen that there is a predominant diameter drifted by wind and that the fractions larger and smaller than this diameter fall off at a more or less constant rate. It is apparent that the sizes to the right and the left of the predominant diameter grade off independently of each other. The predominant diameter of the soil material deposited into dunes from 6 different fields is shown to range from 0.16 mm to 0.35 mm and averages 0.25 mm. These values correspond closely to the size of soil particles forming dune materials in Western Canada(4). There it was found that the predominant diameter of particles in drifts, excluding those from lacustrine clay not represented in the Kansas tests, was likewise 0.25 mm. The predominant diameter of the particles in drifts coincides in some cases fairly closely with their average diameter, but in other cases it is at wide variance with the average diameter.

It should be noted that the material moved about and deposited into dunes by wind constitutes only a part, though a major part, of the total movement. Fine dust, once lifted into the air, is carried great distances away from the eroded area and is deposited on the earth's surface only with rain or after velocity of the wind has slackened considerably. The removal of fine particles from the soil is usually minor in comparison to the rate of movement along the surface of the ground. In some cases, however, it constitutes a much more serious aspect of the wind erosion problem. The wind acts on the soil as a fanning mill on grain, removing fine silt and clay fractions and leaving sand and gravel behind. This sorting action, continued for many years, tends to make the soil coarser in texture, and consequently more erodible, and perhaps less productive, than they were originally.

A typical case illustrating the aspects of the sorting action by a single wind storm occurring in 1948 is shown in Fig. 6. It shows the structure of the soil material moved about and deposited into small dunes in relation to the structure of the residual soil. The drift material contains a very small quantity of particles averaging 0.016 mm and not exceeding 0.05 mm in diameter. The residual soil, or that soil from which the drift material was derived, is shown to contain more than five times the proportion of these fine particles. This indicates that most of these particles in that portion of the soil affected by the wind have been removed from the eroding area. It may be expected that soils containing appreciable quantities of sand will become a little more sandy with each succeeding wind storm, unless the geologic processes *(Continued on page 284)*

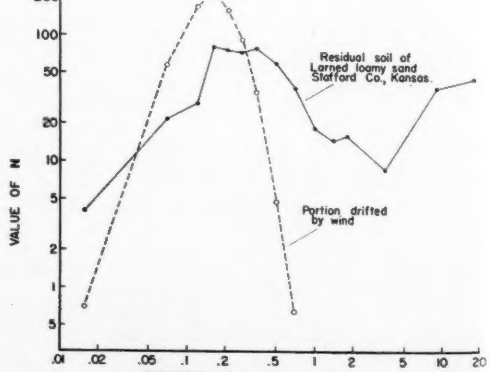


Fig. 6 Dry aggregate composition of a cultivated soil and materials drifted therefrom

Administrative Status of Agricultural Engineering in the USDA

A Message to ASAE Members:

AT THE 1949 annual meeting of the American Society of Agricultural Engineers, the Society considered the U. S. Department of Agriculture section of the report of the Hoover Commission on the reorganization of the executive branch of the federal government. Following the discussion a resolution was adopted requesting the re-establishment of a bureau of agricultural engineering in the Agricultural Research Administration of the Department to encompass all phases of agricultural engineering research.

During the past year your president has used this topic as a major portion of his addresses at the various ASAE section meetings. It appears, however, that some of our members may not clearly understand the internal organization of the USDA and the significance of having their professional interests represented in a single unit in it.

Following is a functional outline of the organization of the USDA approved January 4, 1950, by the Secretary of Agriculture:

- Office of the Secretary
  - Office of Personnel
  - Office of Budget and Finance
  - Office of Plant and Operations
  - Office of Information
  - Library
  - Bureau of Agricultural Economics
  - Office of Foreign Agricultural Relations
  - Office of the Solicitor
  - Office of Hearing Examiners
- Agricultural Research Administration
  - Office of Experiment Stations
  - Bureau of Agricultural and Industrial Chemistry
  - Bureau of Animal Industry
  - Bureau of Dairy Industry
  - Bureau of Entomology and Plant Quarantine
  - Bureau of Human Nutrition and Home Economics
  - Bureau of Plant Industry, Soils, and Agricultural Engineering
- Extension Service
- Forest Service
- Soil Conservation Service
- Rural Electrification Administration
- Commodity Exchange Authority
- Farm Credit Administration
- Farmers Home Administration
- Production and Marketing Administration
- Commodity Credit Corporation
- Federal Crop Insurance Corporation

The re-establishment of a separate Bureau of Agricultural Engineering would involve the inclusion in it of the research work now carried on in this field by the Bureau of Plant Industry, Soils, and Agricultural Engineering, and perhaps the combination with it of other phases of agricultural engineering research work now included in other USDA agencies. Such a bureau would logically belong in the ARA.

There is no question of politics, other than the internal adjustments to be anticipated in any realignment of professional activities and personnel; and no increase required in federal expenditures. Minor financial adjustments would be required in the distribution of administrative and fiscal office operating costs. No new personnel would be added to the federal payroll, with the possible exception of two business office clerks, unless research activities beyond their present scope are authorized by the Congress. The selection of administrative leaders for the new agency would be the responsibility of the ARA administrator and the Secretary of Agriculture.

The alignment of research technologies at the federal level is comparable to that at the state level where agricultural engineering is recognized as a separate department. With four exceptions all state agricultural experiment stations now recognize agricultural engineering as a distinct entity. The primary questions for federal administrative decision are (1) whether engineering is sufficiently important to agriculture and (2) whether the USDA engineering research organization is now sufficiently strong for it to be given recognition on the same administrative plane as the other agricultural technologies.

To understand the present combination in BPISAE it is necessary to know something of the historical background. The Bureau of Plant Industry had its inception some 90 years ago, when it was founded by the Congress as the first agency of what later became the Department of Agriculture. During the years it has developed as a stable, productive research organization.

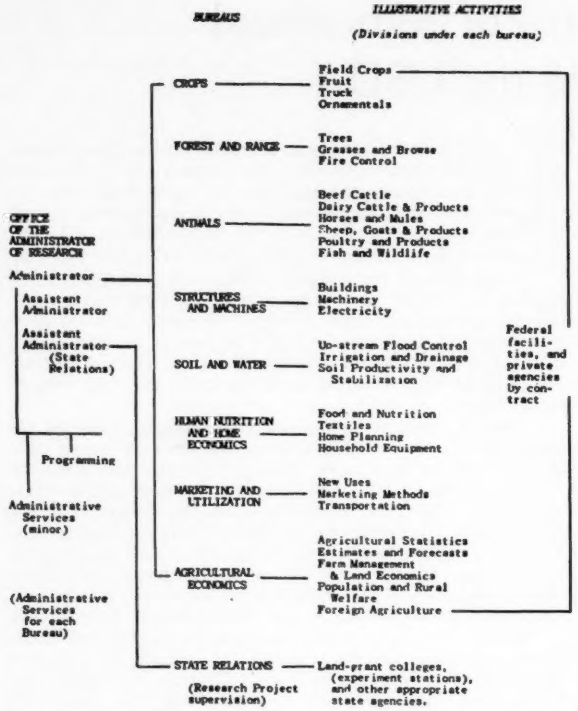
The first phase of agricultural engineering initiated by the Department was the work in irrigation research started at a Florida field station in 1899. During the next decade the work in farm machinery was established, and farm structures a few years later. All were administered in the Office of Public Roads, then an agency in the Department of Agriculture. Following World War I, the engineering work in the agricultural use of surplus war explosives was added, and during most of the 1920-30 period these activities were combined in a division of agricultural engineering in the Office of Public Roads.

In 1930, as a result of representation by professionally conscious agricultural engineers, members of ASAE, the Congress appropriated funds separately to a "Bureau of Agricultural Engineering". It functioned in accord with the traditional Department policy as a research unit and was administered directly by the Secretary. (The ARA grouping for all research agencies was not conceived until 1941.)

In 1937-38 the Secretary of Agriculture effected two administrative changes. The agricultural engineering work in soil and water was withdrawn from the Bureau to provide the nucleus for research in the Soil Conservation Service then being established. A few months later, the remaining work in the Bureau of Agricultural Engineering was combined with chemistry in a new Bureau of Agricultural Chemistry and Engineering. The engineering work did not thrive under the combined administrative organization, however, and many of the engineering personnel transferred to various war agencies. In 1943, the remnants of the engineering research was transferred to the Bureau of Plant Industry and Soils to be revitalized, with the promise that when it had been developed it would be re-established as a separate bureau of agricultural engineering.

Following World War II, recognition of the need for reorganization of the executive branch of the federal government led to the appointment by Congress of the Hoover Commission. Task forces were established by the Commission to consider each of the departments and major agencies. The task force reorganization outline suggested for the Agricultural Research Administration is reproduced here. Members of the task force have subsequently stated that the internal structure of the ARA was not a major concern, that their intent was to indicate a functional research agency organization, that omitting some of the major fields of agricultural engineering was an oversight, that they personally had no objection to all phases of agricultural engineering being grouped together under that name. To date, no reorganization plan affecting the ARA organization has been prepared by the Secretary of Agriculture for the President to present to the Congress. It should be noted that the task force recommendation in the accompanying outline would establish two bureaus for engineering research which is certainly less efficient and more costly than to place all engineering work under a single administrative leadership.

The steady professional growth and the public recognition of agricultural engineering as an essential technology warrant its re-establishment on the federal level as an administrative



A chart of the proposed organization of the USDA Agricultural Research Administration taken from the Task Force Report on Agriculture Activities (Appendix M) prepared for the (Hoover) Commission on Organization of the Executive Branch of the Government

equal with the other major agricultural sciences. It has been said that there are four essential components in modern agriculture: plant sciences, animal sciences, engineering, and management. A research administrator has said that 85 per cent of all agricultural research includes engineering either directly or by implication. An internationally recognized engineering dean is quoted as publicly stating a few months ago that the two types of engineering which hold the most promise for future development are agricultural and chemical engineering.

The present Divisions of Agricultural Engineering in the BPISAE are staffed with competent research engineers, many of whom are nationally recognized as leaders in the profession. Their research productivity has made significant contributions to agriculture and current programs promise even greater future productivity.

Current financial support for the engineering work in the BPISAE is somewhat less than that for home economics and dairy industry each of which have bureau status. Impartial consideration of the engineering research in the USDA can lead only to the conclusion that the time is ripe for it to be given separate status.

Recognition of agricultural engineering in the Agricultural Research Administration would enable our profession to more effectively contribute to agricultural policies and programs of the federal government, would facilitate cooperative relationships with the state colleges, other public agencies and industry, and would make possible a more effective administration of research programs in our various fields of specialization. The re-establishment of a Bureau of Agricultural Engineering is being urged by ASAE, not for the personal benefit of any individual, but because it means more efficient operation of a government agency, and because it is essential if our profession is to receive recognition as a major cooperator in agricultural technology and is to be placed where it can develop its full potential.

FRANK J. ZINK

President, ASAE
Chicago, Ill.
May 10, 1950

Wind Erosion

(Continued from page 282)

of silt and clay formation proceed at a rate equal to, or greater than the rate of removal. It is evident, however, that an annual rate of removal, based on only a single dust storm such as the one shown in Fig. 6, is much greater than the geologic rate of accumulation.

The data in Figs. 5 and 6 also indicate the maximum size of soil grains moved by wind. No quartz fractions greater than 1 mm and only small proportions of sand coarser than 0.5 mm in diameter were found in the drift materials, indicating that erodible quartz grains seldom exceed 0.5 mm in diameter Soil grains having a high degree of porosity, such as those represented by Fig. 5(A), are moved more readily by the wind. Even for this type of soil material, not over 5 per cent exceed 1 mm in diameter.

SUMMARY

The basic nature of problems common to the dynamic action of fluids on the land surface is cited. Studies of the phenomenon of soil erosion by wind initiated at the Manhattan, Kansas, headquarters are outlined briefly.

Experiences with the soil-blowing tunnel are discussed. Some of the aerodynamic characteristics of the tunnel developed at the Manhattan laboratory are given.

Formulas which have been applied to the description of surface wind movement are presented. Demonstrated, also, are problems common to the application of these relationships to the phenomenon of wind movement above field surfaces.

The types of soil movement and forms of erosion caused by wind are summarized, and some of the physical characteristics of several soil materials blown about and drifted into small dunes in the spring of 1948 are presented.

REFERENCES

1 Bagnold, R. A.: The Physics of Blown Sand and Desert Dunes. William Morrow & Company, New York (1943).

2 Brunt, David: Physical and Dynamical Meterology. Cambridge University Press (1944). (An account of Prandtl's treatment of the subject is given in Chap. 12, Sec. 147 and 148).

3 Chepil, W. S.: Dynamics of Wind Erosion: IV. The Translocating and Abrasive Action of the Wind. *Soil Sci.* 61:167-177 (1946).

4 Chepil, W. S.: Dynamics of Wind Erosion: VI. Sorting of Soil Material by the Wind. *Soil Sci.* 61:331-340 (1946).

5 Free, E. E.: The Movement of Soil Material by the Wind, with a Bibliography of Eolian Geology by S. C. Stuntz and E. E. Free. U.S.D.A. Bureau of Soils Bulletin No. 68 (June 15, 1911).

6 Joy, Edgar C.: Annual Report on Wind Erosion Investigations in South Dakota. South Dakota Agr. Exp. Sta. and U.S.D.A. Soil Conservation Service. Unpublished (1941).

7 Kalinske, A. A.: Movement of Sediment as Bed Load in Rivers. *Transactions of Am. Geophysical Union,* vol. 28, no. 4, pp. 615-620 (1947).

8 Karman, Th. von: Turbulence and Skin Friction. *Jour. Aeronautical Sci.,* vol. 1, no. 1, p. 1, (1934).

9 Kucinski, Karol J.: Some Properties of Wind Blown Soils of Massachusetts. Mass Agr. Exp. Sta. and U.S.D.A. Soil Conservation Service. Unpublished thesis (June 1946).

10 Malin, James C.: Dust Storms, 1861-1880. *Kansas Historical Quarterly* (August, 1946).

11 Malina, Frank J.: Recent Developments in the Dynamics of Wind-erosion. *Transactions of Am. Geophysical Union* (1941).

12 Progress Report of Investigation on Wind Maker Studies. Dept. of Agr. Eng., Kansas State College and Division of Research, Soil Conservation Service, Amarillo, Texas. Unpublished (1942).

13 Report of investigations. Soil Research Laboratory, Swift Current, Sask., Canada (1943).

14 Rouse, Hunter: Fluid Mechanics for Hydraulic Engineers. McGraw-Hill Book Co., Inc. (1938). (A summary of Nikuradse's experiments is given in Chap. 12, Sec. 58).

A Quantitative Method for Determining Ground-Water Characteristics for Drainage Design

By John G. Ferris

IN THE course of the state-wide investigation of the ground-water resources of Michigan, by the U. S. Geological Survey and the Geological Survey Division of the Michigan Department of Conservation, it has been the policy of the cooperating agencies to conduct research on the flow of underground waters in order to develop practical solutions to water problems that confront agriculture, industry, recreation, and the public supply. Oft-repeated among the requests from agricultural and recreational interests is the demand for information as to the effect of drains on lake levels and the regional water table. These requests arise in areas where arable muck lands lie contiguous to lakes that are highly developed by recreational interests. With evapotranspirative losses at their peak during the summer months, there is generally a recession of lake levels during this period, even with normal rainfall. Drought periods, which are not uncommon to Michigan summers, accentuate the lake-level recession and bring into sharp focus all uncontrolled drainage in areas bordering the lakes. The term "uncontrolled" is used in the sense that past drainage practice was designed for removal of the maximum discharge during the spring season, with no control or limitation on drainage during the drought periods. The recent rapid growth of irrigation in Michigan faces us now with the incongruous need for replacing soil moisture that the drains remove during the growing season. Within the past few years, several farmers have recognized the need for water conservation by stop-logging or otherwise controlling drains for use as subirrigation systems during drought periods.

In defense against drainage abuse in some areas, recreational interests have taken their cue from agriculture's organization of drainage districts and have organized lake owners to seek injunctions against drainage improvements. Both agricultural and recreational interests have sought the aid of the State Department of Conservation as an impartial source of knowledge on this controversial subject. A review of the objectives of both interests shows that they are essentially the same, and one is unable to explain the cause of controversy except on the basis of a mutual misunderstanding of interests. The lake resident is most aware of the need for maintaining moderate to high lake stages during the summer season, but does not recognize the need for adequate outflow capacity and lowered stage during the spring and winter months, to minimize flood and ice damage to lakeside structures. The farmer is most aware of the need for large outflow and drainage capacity during the spring high-water stage, but does not recognize the need for limiting drainage and for subirrigating during the dry summer months. The needs of both interests could best be served by a program of water-level control that would permit either the ready discharge from, or the storage of water in, the lake and contiguous drains.

In an effort to develop rational methods for determining the effect of drains on lake levels and on the regional water table, the State and Federal Geological Surveys set up cooperative research projects at Gun Lake in Barry County and at Lee Lake in Calhoun County, in response to requests from recreational and agricultural interests in these areas for information. The wholehearted cooperation of interested parties from both groups made it possible to conduct intensive experiments on existing drains, for the purpose of checking the field application of drainage theory.

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at East Lansing, Mich., June 1949, as a contribution of the Soil and Water Division, and published by permission of the Director of the U. S. Geological Survey.

The author: JOHN G. FERRIS is district engineer, Ground Water Branch, U. S. Geological Survey, Lansing, Mich.

Hydraulics of Drains. When a drain discharges, ground-water levels in the vicinity are lowered, with a resultant loss of storage. In a water-table aquifer, water is yielded from storage by the dewatering of previously saturated sediments. In an artesian aquifer, stored water is released by compaction of the aquifer and associated confining beds as the pressure declines. This storage property of an aquifer is quantitatively expressed by the coefficient of storage, S, which has been defined(1) as the volume of water in cubic feet that is discharged from each vertical column of the aquifer having a base 1 ft square as the water level falls 1 ft. For a water-table aquifer, S corresponds essentially to the specific yield or effective porosity. For an artesian aquifer, S indicates the water released from storage by the compaction of a vertical column of the water-bearing material and associated beds having a base 1 ft square.

The movement of water through porous materials follows a law developed experimentally by Darcy(2) which may be modified for use with the transmissibility coefficient introduced by Theis(3). The coefficient of transmissibility is defined as the rate of flow of water, in gallons per day at the prevailing temperature, through a vertical strip of the aquifer 1 ft wide and extending the full saturated height, under a hydraulic gradient of 1 ft per ft. It is equal to the product of the coefficient(4) of permeability and the saturated thickness of the flow section. Using the above terminology, the modified Darcy formula is written:

$$Q_d = TIW \qquad [1]$$

where Q_d = discharge in gallons per day
T = coefficient of transmissibility, in gallons per day per foot
I = hydraulic gradient, in feet per foot
W = width of cross section, in feet.

To simplify the mathematical treatment of the flow of ground water toward a drain, the following assumptions are made: (a) The aquifer is homogeneous, isotropic, and of infinite areal extent; (b) the discharging drain completely penetrates the aquifer and is of infinitesimal width; (c) the aquifer is bounded by impermeable strata above and below; (d) flow is laminar and unidimensional; (e) the coefficient of transmissibility is constant at all places and at all times, and (f) the coefficient of storage is constant and water is released from storage instantaneously with and proportionally to the decline in head. The degree to which these assumptions are justified may be determined by testing our solution against field observations.

A generalized section through an aquifer intersected by a drain is shown by Fig. 1. The flow through the inner face of the elemental prism of unit width is expressed from equation [1] as

$$Q_x = TI_1W_1 = -T\frac{\partial s}{\partial x} \qquad [2]$$

The slope of the piezometric surface at the outer face of the prism is determined as follows:

$$I_2 = I_1 + \frac{\partial \frac{\partial s}{\partial x}}{\partial x}dx = \frac{\partial s}{\partial x} + \frac{\partial^2 s}{\partial x^2}dx \qquad [3]$$

Then the flow through the outer face of the prism is given by

$$Q_{(x+dx)} = TI_2W_2 = -T\left[\frac{\partial s}{\partial x} + \frac{\partial^2 s}{\partial x^2}dx\right] \qquad [4]$$

The change in storage within the prism is expressed by

$$\frac{dV}{dt} = dx\frac{\partial s}{\partial t}S \qquad [5]$$

For the conservation of matter the difference in flow between the inner and outer faces of the prism must be equal to the rate of change in storage within the prism.

$$Q_x - Q_{(x+dx)} = \frac{dV}{dt} \qquad [6]$$

Substituting in equation [6] the values given by equations [2], [4], and [5], there results

$$-T\frac{\partial s}{\partial x} + T\left[\frac{\partial s}{\partial x} + \frac{\partial^2 s}{\partial x^2}dx\right] = dx\frac{\partial s}{\partial t}S$$

$$\frac{\partial^2 s}{\partial x^2} = \frac{S}{T}\frac{\partial s}{\partial t} \qquad [7]$$

This is the fundamental differential equation for the flow of water toward a drain in an elastic artesian aquifer. It is analogous to a well-known differential equation for the flow of heat in solids as given by Carslaw(5) and by Byerly(6). It has been utilized in hydrology by Jacob(7) by Kirkham(8), and by Werner(9). Particular solutions of this equation for the steady state were used earlier by Slichter(10) and by Gardner (11).

The next step is to find a particular solution of the differential equation that will satisfy the boundary conditions imposed by the field problem. The mathematics may be simplified by first solving the problem of an instantaneous, hydrodynamic line sink. In the field this would entail a hypothetical mechanism that would instantaneously remove from the drain a known volume of water, V, in an infinitesimal time, dt. For the physical picture one might visualize the water scoop as used by high-speed locomotives to pick up water in transit. Among the boundary conditions to be satisfied are the following:

When $t = 0$, $s = 0$ for all values of x.

When $x = \infty$, $s = 0$.

We assume the form of a solution and test it against equation [7] and the above boundary conditions.

Let

$$s = Ct^{-\frac{1}{2}}e^{-\frac{Dx^2}{t}} \qquad [8]$$

Then

$$\frac{\partial s}{\partial x} = \frac{-2CDxe^{-\frac{Dx^2}{t}}}{t^{\frac{3}{2}}} \qquad [9]$$

$$\frac{\partial^2 s}{\partial x^2} = \frac{-2CDe^{-\frac{Dx^2}{t}}}{t^{\frac{3}{2}}} + \frac{4CD^2x^2e^{-\frac{Dx^2}{t}}}{t^{\frac{5}{2}}} \qquad [10]$$

$$\frac{\partial s}{\partial t} = -\frac{Ce^{-\frac{Dx^2}{t}}}{2t^{\frac{3}{2}}} + \frac{CDx^2e^{-\frac{Dx^2}{t}}}{t^{\frac{5}{2}}} \qquad [11]$$

Substituting equations [10] and [11] in equation [7] we obtain

$$\frac{-2CDe^{-\frac{Dx^2}{t}}}{t^{\frac{3}{2}}} + \frac{4CD^2x^2e^{-\frac{Dx^2}{t}}}{t^{\frac{5}{2}}} = \frac{S}{T}\left[-\frac{Ce^{-\frac{Dx^2}{t}}}{2t^{\frac{3}{2}}} + \frac{CDx^2e^{-\frac{Dx^2}{t}}}{t^{\frac{5}{2}}}\right]$$

Equating coefficients of the terms of like exponent,

(a) $-2CD = -\frac{SC}{2T}$ (b) $4CD^2 = \frac{S}{T}CD$

$D = \frac{S}{4T}$ $D = \frac{S}{4T}$

Then equation (8) becomes:

$$s = Ct^{-\frac{1}{2}}e^{-\frac{Sx^2}{4Tt}} \qquad [12]$$

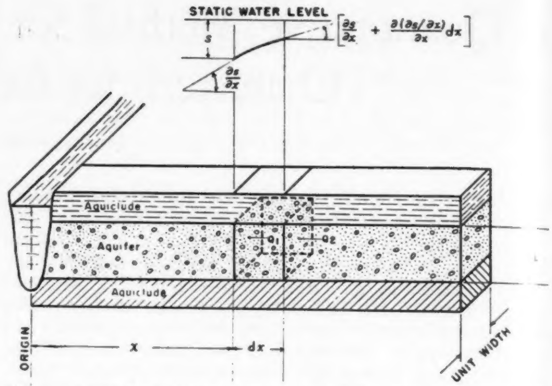


Fig. 1 Generalized section through an aquifer that is intersected by a drain

The coefficient C may be determined by a third boundary condition that follows from the law of the conservation of matter. The total quantity of water yielded by the aquifer from storage must equal the volume withdrawn from the sink. The integral over the cylinder of depression is set up as follows:

$$V = \int_0^\infty Ss\,dx \qquad [13]$$

$$V = \int_0^\infty SCt^{-\frac{1}{2}}e^{-\frac{Sx^2}{4Tt}}dx$$

Let

$$u = x\sqrt{\frac{S}{4Tt}} \qquad [14]$$

Then

$$du = \sqrt{\frac{S}{4Tt}}\,dx$$

$$V = \int_0^\infty \frac{SC}{t^{\frac{1}{2}}}e^{-u^2}\frac{du}{\sqrt{\frac{S}{4Tt}}}$$

$$V = \frac{SC}{\sqrt{\frac{S}{4T}}}\int_0^\infty e^{-u^2}du = C\sqrt{4ST}\int_0^\infty e^{-u^2}du$$

$$V = C\sqrt{4ST}\left[\frac{\pi}{2}\right] = C\sqrt{\pi ST}$$

$$C = \frac{V}{\sqrt{\pi ST}} \qquad [15]$$

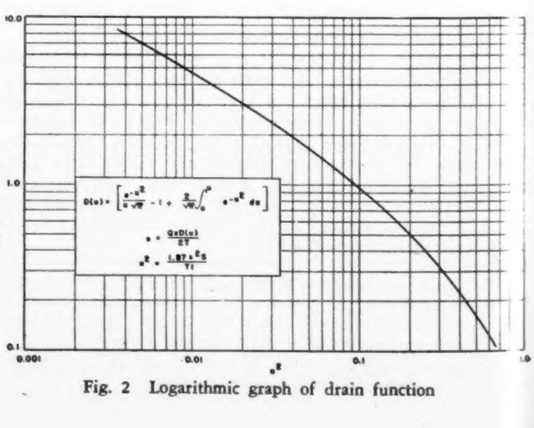


Fig. 2 Logarithmic graph of drain function

Substituting this value of C in equation [12]

$$s = \frac{V e^{-\frac{x^2 S}{4Tt}}}{\sqrt{\pi T S t}} \quad [16]$$

To this point we have considered only the half space shown by Fig. 1. For the drain we normally have flow from both sides and thus, to fit the problem of the drain in an infinite space, we replace V by V' where $V' = 2V$.

$$s = \frac{V' e^{-\frac{x^2 S}{4Tt}}}{2\sqrt{\pi T S t}} \quad [17]$$

Equation [17] is analogous to the heat-conduction formula for the plane sink as given by Carslaw(12). This equation was extended by Theis(13) to the problem of a drain discharging at a constant rate. The discharge of a drain at a constant rate Q over time t' is equivalent to the summation of an infinite number of instantaneous sinks that operate prior to the time of observation t' at times varying from O to t'. The volume V' discharged in an infinitesimal time will be Qdt. Substituting in equation [17], and noting that x is constant if we compute the effect at a fixed distance from the drain:

$$s = \frac{Q}{2\sqrt{\pi T S}} \int_0^{t'} \frac{e^{-\frac{x^2 S}{4Tt}}}{\sqrt{t}}\, dt \quad [18]$$

Let $M = \sqrt{\frac{x^2 S}{4T}}$ and $u = \sqrt{\frac{x^2 S}{4Tt}}$

Then $u = \frac{M}{\sqrt{t}}$ or $t = \frac{M^2}{u^2}$

$$dt = -\frac{2M^2}{u^3}\, du \quad [19]$$

When $t = t'$ $u = \frac{M}{\sqrt{t'}}$; $t = O$ $u = \infty$

$$s = \frac{Q}{2\sqrt{\pi T S}} \int_\infty^{\frac{M}{\sqrt{t'}}} \frac{e^{-u^2}}{\frac{M}{u}} \left[-\frac{2M^2}{u^3}\, du\right]$$

$$s = -\frac{QM}{\sqrt{\pi T S}} \int_\infty^{\frac{M}{\sqrt{t'}}} \frac{e^{-u^2}}{u^2}\, du \quad [20]$$

$$s = \frac{QM}{\sqrt{\pi T S}} \int_{\frac{M}{\sqrt{t'}}}^\infty \frac{e^{-u^2}}{u^2}\, du = \frac{Qx}{2T\sqrt{\pi}} \int_{\frac{M}{\sqrt{t'}}}^\infty \frac{e^{-u^2}}{u^2}\, du \quad [21]$$

For integration by parts let $w = e^{-u^2}$ and $dv = \left[\frac{1}{u^2}\right] du$

Then $\int w\, dv = vw - \int v\, dw$

or $$s = \frac{Qx}{2T\sqrt{\pi}} \left[\frac{-e^{-u^2}}{u} - 2\int e^{-u^2}\, du\right]_u^\infty$$

$$s = \frac{Qx}{2T\sqrt{\pi}} \left[\frac{e^{-u^2}}{u} - 2\int_u^\infty e^{-u^2}\, du\right]$$

$$s = \frac{Qx}{2T} \left[\frac{e^{-u^2}}{\sqrt{\pi}\, u} - \frac{2}{\sqrt{\pi}} \int_u^\infty e^{-u^2}\, du\right]$$

$$s = \frac{Qx}{2T} \left[\frac{e^{-u^2}}{\sqrt{\pi}\, u} - 1 + \frac{2}{\sqrt{\pi}} \int_0^u e^{-u^2}\, du\right] \quad [23]$$

The quantity in brackets may be represented as $D(u)$, which is read "drain function of u." Then equation [23] is written as

$$s = \frac{Qx}{2T} D(u) \quad [24]$$

Generally T, the coefficient of transmissibility, is expressed in units of gallons per day per foot and these units will apply to Q.

$$[24]\ s = \frac{Qx\, D(u)}{2T} \qquad s\,(\text{ft.}) = \frac{Q(\text{gals/day/ft})\ x\ (\text{ft})}{T(\text{gals/day/ft})}$$

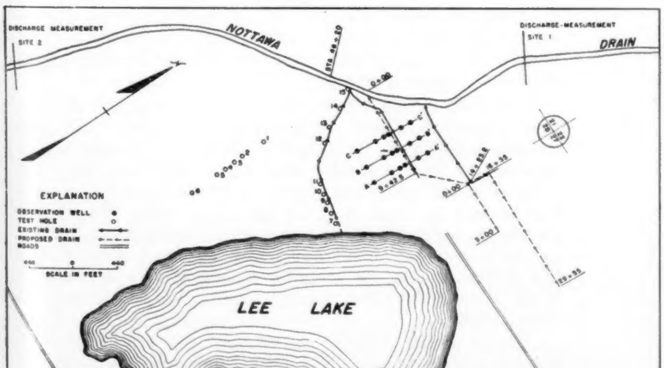
$$[14]\ u = x\sqrt{S/4Tt} \text{ or } u^2 = \frac{x^2 S}{4Tt} =$$

$$\frac{x^2(\text{ft}^2)}{4T\ (\text{gals/day/ft})\ t(\text{day})} \times \frac{1}{\text{ft}^3/7.48 \text{ gals}}$$

in the gpd/ft units,

$$u^2 = \frac{1.87\, x^2 S}{Tt} \quad [25]$$

Then the system of units to be used with equations [24] and



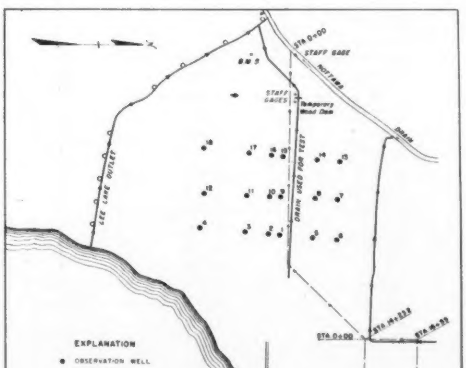


Fig. 3 (*Left*) Map of Lee Lake area in Newton Township, Calhoun County, Michigan, showing site of drain experiment • Fig. 4 (*Right*) Location of observation wells for Lee Lake drain experiment

[25] is as follows:

s = drawdown in feet at distance x, at time t

x = distance from drain to observation well, in feet

Q = discharge of drain, in gallons per day per foot of drain

S = coefficient of storage

T = coefficient of transmissibility, in gallons per day per foot.

From inspection of equations [24] and [25] it follows that if s can be measured at several values of t, and if x and Q are known, then S and T can be determined. However, the occurrence of two unknowns and the nature of the drain function make exact analytical solution impossible and trial solution most laborious. To simplify the usage of this equation we resort to a graphical method of superposition. Assuming values of u, compute the corresponding $D(u)$ to derive Table 1. From these data plot on logarithmic coordinate tracing paper values of u or u^2 versus $D(u)$, as shown by Fig. 2. For convenience in subsequent computation the type curve of Fig. 2 was plotted as u^2 versus $D(u)$.

Rearranging equations [24] and [25] and taking the log of both sides there follows:

$$\log s = \log(Qx/2T) + \log D(u) \quad [26]$$

$$\log(x^2/t) = \log(T/1.87S) + \log u^2 \quad [27]$$

Inasmuch as Q, x, T, and S are constant, it follows that, if a plot of log s versus log (x^2/t) is superimposed on a plot to the same scale of log $D(u)$ versus log u^2 and translated so that the observed data coincide with the type curve, then the displacement of the ordinate axes is the constant, log $(T/1.87S)$, and the displacement of the abscissas is the constant, log $(Qx/2T)$. When the two plots are matched in a position of congruity the double coordinates of any match point permit solution of equations [24] and [25].

EXPERIMENTS AT LEE LAKE

To test these equations against field observations, experiments were made on existing drains at Gun Lake in Barry County and at Lee Lake in Calhoun County, Mich. For demonstration the Lee Lake data are used because of the simplicity of drain pattern. The site of the hydrogeologic test is shown

TABLE 1. VALUES OF $D(u)$, u and u^2 FOR DRAIN FUNCTION

u	u^2	$D(u)$
0.0600	0.0036	8.468
0.0700	0.0049	7.109
0.0800	0.0064	6.130
0.0900	0.0081	5.331
0.1000	0.010	4.714
0.1140	0.013	4.008
0.1265	0.016	3.532
0.1414	0.020	3.079
0.1581	0.025	2.657
0.1732	0.030	2.354
0.1871	0.035	2.109
0.2000	0.040	1.943
0.2236	0.050	1.658
0.2449	0.060	1.441
0.2646	0.070	1.282
0.3000	0.090	1.049
0.3317	0.110	0.8810
0.3605	0.130	0.7598
0.4000	0.160	0.6284
0.4359	0.190	0.5324
0.4796	0.230	0.4384
0.5291	0.280	0.3517
0.5745	0.330	0.2895
0.6164	0.380	0.2434
0.6633	0.440	0.2008
0.7071	0.500	0.1837
0.7616	0.580	0.1345
0.8124	0.660	0.1094
0.8718	0.760	0.0864
0.9486	0.900	0.0623
1.0000	1.000	0.0507

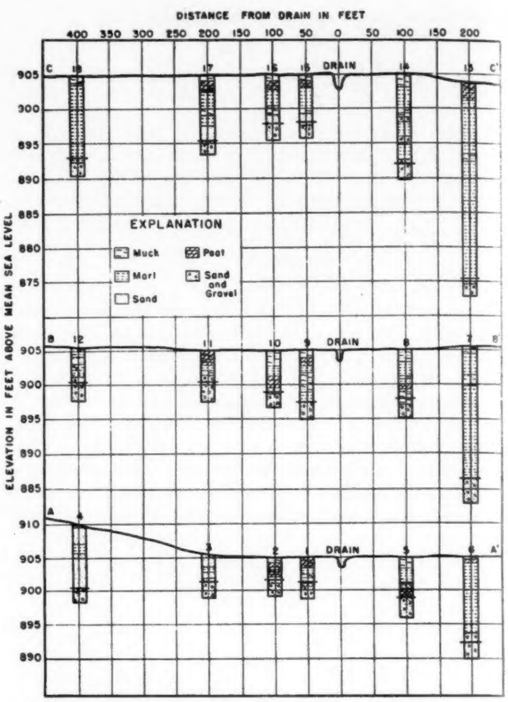


Fig. 5 Geologic sections along observation-well lines transverse to experimental drain at Lee Lake

in Fig. 3. Further detail of the hydraulic experiment site is shown by Fig. 4. Test borings were made and observation wells were installed by the engineering section of the Michigan Department of Conservation at sites indicated by Figs. 3 and 4. A temporary dam with a V-notch weir was constructed in an existing shallow drain which nearly coincides with the axis of the proposed drain. Staff gages were installed in Lee Lake, in Nottawa drain, and above and below the temporary dam. Instrumental levels were run to all gages, test holes, and observation wells.

Geologic sections based on the test borings were drawn for each line of observation wells crossing the drain and are reproduced as Fig. 5. The surface of the muck-peat-marl to sand contact shown by these sections parallels in general the present land surface, which slopes toward Nottawa drain and toward the deeper part of the ancient lake in which the surficial deposits were formed. A soil survey(14) of Calhoun County indicates that the soils of Newton Township are principally sandy loams that are overlain in the lowland area by deposits of muck and marl.

In preparation for the test, the weir was closed for more than a week to observe the recovery of the water table in the vicinity of the drain. During this period repairs were required to eliminate leakage under and around the temporary dam. After a period of several days of stable water levels the weir was opened at 11:23 a.m. on March 2, 1949. Periodic and continuing measurements of water level were made in all observation wells and at all staff gages for about 24 hr. A thaw that started during the morning of March 3 caused recharge to the water table about midday, and measurements were then discontinued.

Values of the observed drawdown, s, and the corresponding x^2/t were computed and plotted for each of the 18 observation wells. The sample plot in Fig. 6, shows one well from a group about 200 ft distant from the drain. A comparison of these plots indicates that the earlier observations, particularly for wells near the drain, underlie the trace of the drain function. The smaller drawdowns observed near the start of the test and near the drain are the result of field difficulties en-

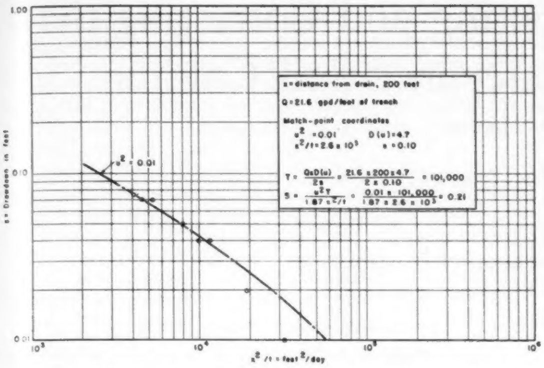


Fig. 6 Logarithmic plot of drawdown of water level in observation well No. 11 at site of drain experiment

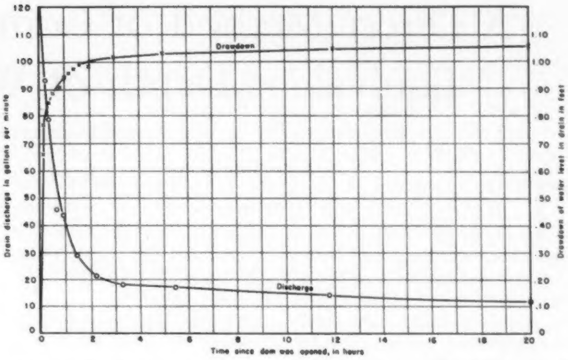


Fig. 7 Graph showing trend of discharge from and drawdown of water level in experimental drain following removal of dam at test site

countered in lowering the drain level to the desired stage. Original planning proposed the removal of the V-notch weir plate during the first part of the test to permit rapid discharge of stored water in the drain, but swelling and warping of the wood supporting the weir made this procedure impractical. As a consequence, more than 2 hr elapsed after the opening of the control gate before the drain discharge approached the constancy assumed for the derivation of the drain function. Plots of the trend in discharge and net drawdown of water level in the drain are shown by Fig. 7. The deficiency of drawdown in the drain during the early part of the test accounts for the deficient drawdown at the observation wells in the same period. In addition to weir measurements, volumetric determinations of drain discharge were made throughout most of the test period, and these results provided the basis for Fig. 7.

The field-observation plots are superimposed on the type-curve plot and, with the axes maintained parallel, are translated to a position of congruity. In selecting the best fit, greater weight is attached to the latter time values or the smaller x^2/t values because the discharge during this period was more nearly constant and thus in better agreement with the assumptions. With the observation-well plot superimposed on and congruent with the type curve, any point may be selected and pinned through both plots. The double coordinates of this match point are noted from the field-data curve and from the type curve. A sample computation of the T and S coefficients from these coordinates is shown in Fig. 6. The average of the 18 independent plots gives a coefficient of transmissibility, T, of 101,000 gal per day per foot and a coefficient of storage, S, of 0.19.

The greatest departure of the field conditions from the initial assumptions is the limited penetration of the drain into the aquifer. It has been shown by Jacob(15) that this deviation is not serious in the discharging-well problem if the distance from the point sink to the observation well is more than twice the thickness of the aquifer. An inspection of water level drawdown curves would show that the data for observation wells 100 ft or more distant from the drain fit the type curve better and over a greater length than equivalent data from nearby wells.

A qualitative check of the computed T and S values is obtained by correlation with geologic evidence. The storage coefficient, S, of 0.19 indicates that water-table conditions prevail in the test area, and this value is then equivalent to the specific yield of the unwatered material. A specific yield or effective porosity of 0.19 for the sandy organic deposits reported in the test holes is of the proper order of magnitude for such materials. Available records of oil or gas test wells drilled within a few miles of Lee Lake show a range in thickness of the glacial drift from 42 to 82 ft, with an average of 50 ft near the lake. Using the computed T value of 101,000 gpd per ft and the estimated thickness of 50 ft, the coefficient of permeability is computed as 101,000 ÷ 50, or 2,000 gals per day per sq ft. This value is comparable to permeability coefficients determined for similar deposits in areas where adequate geologic control was available.

A quantitative check against the computed T value was made with the assistance of the Surface Water Branch of the U. S. Geological Survey by current-meter measurements of discharge at sites 1 and 2 noted on Fig. 3. The discharge measurements were made on June 2, 1949, during a period when direct surface runoff was not occurring and the flow of Nottawa drain represented ground-water discharge or "base flow." These results are summarized by Table 2. For the 57-sq-mi drainage area above gaging site 1, the mean pickup of base flow per square mile is calculated as 35.5 ÷ 57, or 0.62 sec-ft. To estimate the pickup of base flow in the 1-mile reach between sites 1 and 2, the intervening area was divided into two parts, the area west of Nottawa Drain and the area east of the drain. It was assumed that the west-area increment of 1.3 sq mi contributes base flow at the mean rate of the area upstream from site 1, or a total pickup of 1.3 x 0.62 = 0.8 sec-ft. The pickup from the east area may be computed from equation [1], using the T value determined from the drain experiment. The effect of the lateral and sublateral drains is neglected in the estimate because the low stages that prevailed at the time of the seepage tests made the subdrains inoperative. The gradient from Lee Lake to Nottawa drain is based on the observed head difference of 6.1 ft and the measured distance of 2,400 ft from the drain to an assumed parallel through the near quarter point of the lake area. The choice of the quarter point for centering the leakage area is arbitrary, but is intended to show that infiltration from the lake bottom must occur over an appreciable area and not only at the shore line. From equation [1] there follows:

$$
\begin{aligned}
Q &= TIW \\
&= 101{,}000 \times 6.1/2400 \times 5{,}280 \\
&= 1{,}340{,}000 \text{ gals per day} \\
&= 2.1 \text{cfs.}
\end{aligned}
$$

(Continued on page 291)

TABLE 2. SUMMARY OF DISCHARGE MEASUREMENTS ON NOTTAWA DRAIN NEAR LEE LAKE IN CALHOUN COUNTY, MICH.

Gaging section no.	Measurement no.	Date	Time (p.m.) Start	Finish	Water level in feet above mean sea level Lee Lake	Nottawa Drain	Measuring section Area, sq ft	Mean velocity, fps	Discharge, cfs	Mean discharge cfs
1	1	6/2/49	1:53	3:02	904.94	898.86	41.2	0.88	36.1	35.5
1	2	6/2/49	2:45	3:40	904.94	898.86	41.4	.84	34.9	
2	1	6/2/49	1:40	2:00	904.94	898.86	19.9	1.94	38.6	38.0
2	2	6/2/49	5:40	6:00	904.94	898.86	19.6	1.91	37.4	

A Direct Method of Computing and Correcting the Equivalent Depth of Water in a Soil Column

By James O. Henrie

THE inaccuracies of finding the equivalent depth of water in a soil column have long been recognized by leading irrigation specialists in this country. New and elaborate sampling equipment has been developed and special sampling techniques have been presented. Many of these obtain the desired results but their cost is often not justified.

A direct, inexpensive and accurate method of obtaining the equivalent depth of water in inches in a soil column is presented in this paper.

This problem is increasing in importance because of the increasing soil moisture studies in relation to the consumptive use of water.

The purpose of this paper is to show a direct method of computing the equivalent depth of water in a column of soil when sampled with the improved King soil-sampling tube (improved by Veihmeyer), or any other sampling device that cuts a circular core out of the soil. It also describes a correction to be used with this sampling method to correct for a gain or loss of core. This paper therefore indicates a fast and accurate means of computing the inches of water in a soil sample after the actual sampling has been done. A suggested form for the field data, computations, and corrections is also shown.

Method Now Used. The method now used for computing the equivalent depth of water in a soil column is based on the formula,

$$d = \frac{Pw\ As\ D}{100}$$

where d is the equivalent inches of water in a soil column of depth D, Pw is the per cent water on a dry weight basis, and As is the apparent specific gravity.

The weight of moisture is found by subtracting the dry weight of soil plus can from the wet weight of soil plus can. Then the dry weight of soil is found by subtracting the weight of the can from the weight of dry soil plus can. The elements in the formula are computed from this data and the inches of water are thus obtained.

This may take only a few minutes, but a shorter and less cumbersome method may be used which gives identical results and lends itself well to the correction which will be explained.

The Direct Method. The weight of moisture in the soil column in grams is found as before. One gram of water occupies one cubic centimeter of space; therefore, the weight of moisture in the soil column in grams is numerically equal to the volume of water in cubic centimeters. Dividing this volume by the area of the cutter of the soil sampler gives the height of moisture in the column in centimeters. Dividing this by 2.54, the number of centimeters in an inch, gives the equivalent inches of water in the soil column. These conversion factors can be combined, thus eliminating some of the computation work. The formula is shown in its shortest form and is shown to be numerically correct by the following:

$$\text{Inches of water} = \text{weight of water (g)} \times \frac{1\ (\text{cm})^3}{1\ (\text{g})} \times \frac{1}{\frac{\pi D^2}{4}\ (\text{cm})^2} \times \frac{1\ (\text{in})}{2.54\ (\text{cm})}$$

$$= \frac{\text{wt. of water}}{\frac{\pi}{4} D^2 \times 2.54}$$

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

The author: JAMES O. HENRIE, graduate civil engineering student, Utah State Agricultural College, Logan.

but, $(\pi/4) \times 2.54 = 2$; therefore

$$\text{Inches of water} = \frac{\text{weight of water}}{2D^2}$$

or letting $C = 1/2D^2$, then

$$d = C\,W \qquad [1]$$

where d = equivalent height of water in inches

W = weight of water in grams in the soil sample

$C = 1/2D^2$, where D equals the inside diameter of the cutter of the soil-sampler in centimeters.

This equation can be shown to be dimensionally correct. The numeral "2" has the dimensions of gm/cm^2-in. Using the FLT system, C has the dimensions of $1/(F/L^3) \times L^2 = L/F$, and equation [1] has the dimensions of $(L/F) \times F = L$, which shows that the equation is dimensionally correct. It should be noted, however, that the dimensions depend on equating grams of water to cubic centimeters.

The factor $1/2D^2$, C, is a constant for any sampling tube. The dimensions of $2D^2$ are cm^3/in; or, they represent the volume of a cylinder having a diameter of D cm and a height of 1 in. It can readily be seen that the total volume of water divided by the volume per inch gives the inches of water as was shown by equation [1].

Equation [1] gives the equivalent inches of water in the length of core sampled. This length is generally one foot. The sum of the inches of water in each foot gives the total equivalent inches of water in the soil down to the depth sampled.

A second procedure is to find the total weight of water by subtracting the total of the dry weights from the total of the wet weights and multiplying this weight by C to get d.

Computing the inches of water by equation [1] is limited, though, because sampling must be done with a soil sampler that cuts a circular core. This does not seriously limit use of this equation, however, because today most soil sampling is done with the improved King soil sampler or a similar sampler that cuts a circular core. This method is not limited by the deformation of the core during or after sampling.

Correction for Loss or Gain of Core. If it is desired to know the inches of water, d, in each foot, or if it is felt that

FIELD DATA, COMPUTATIONS, AND CORRECTIONS OF THE EQUIVALENT INCHES OF WATER IN A SOIL COLUMN

Date ____________ Farm ____________

Area ____________ Crop ____________

Tube number ____________ Tube constant, C, $\frac{1}{2D^2}$ ____________

Depth of Sample	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	Total
(1) Can number									
(2) Wt. wet soil + can									
(3) Wt. dry soil + can									
(4) Wt. of moisture, (2)-(3)									
(5) In. of water, (4) x C									
(6) Wt. dry soil + can									
(7) Weight of can									
(8) Dry wt. of soil, (6)-(7)									
(9) Average dry wt. of core									
(10) Corrected inches of water, [(9)/(8)] x (5)									

Remarks:

there has been some loss or gain of core while sampling, the following correction should be used.

It is based on the belief that the dry weight of the core in each foot sampled should remain constant when repeated samples are taken from the same plot. No matter how careful the person sampling the soil is, he doesn't get exactly the one foot of core, so the dry weights in that same foot vary from sample to sample.

If all of the dry weights of core in the same foot taken from the same plot are averaged, excluding any values extremely high or low which indicate a definite gain or loss of core, this can be assumed to be the correct average dry weight of that foot of core. Further assuming that a particular core, whether a little short or long, is representative of the core and moisture condition of the particular foot it represents, the following ratio can be set up:

$$\frac{\text{Corrected inches of water in the core}}{\text{Inches of water in the core}} = \frac{\text{Average dry weight of core}}{\text{Dry weight of core}}$$

or letting Wc = dry weight of core

Wca = average dry weight of core

d = inches of water in the core

d' = corrected inches of water in the core,

then $$d' = \frac{Wca}{Wc} \times d \qquad [2]$$

If different size soil tubes are used, the dry weights are all converted to the same basis by multiplying the dry weights by the ratio of the diameters squared, or of the areas, of the larger or smaller soil tube cutter to that of the tube chosen to be the standard. This tube will generally be the one with which most of the samples are taken, so that the fewest number of dry weights will have to be converted.

If a larger and more accurate sampler, such as the one developed cooperatively at the Utah State Agricultural College which obtains a four-inch undisturbed core, can be used once or twice in each plot, the dry weight can be accurately obtained and converted to the dry weight of each core by the method described above. This dry weight could then be used in place of the average dry weight in equation [2].

A correction similar to this has been suggested on a constant apparent specific gravity basis. This would be essentially the same as the correction explained above because the apparent specific gravity is directly proportional to the dry weight per foot of core.

Form for Field Notes and Computations. The accompanying form for field notes, computations, etc., will enhance the use of this direct method of computing and correcting the inches of water in a soil column. The space for remarks might include dates of irrigations, moisture conditions, changes in sampling procedure, loss of core, and general observations regarding precipitation.

CONCLUSIONS

The method of computing the inches of water in a soil column as explained in this paper will decrease the work of computations to the extent that the inches of water can be found with little trouble immediately after weighing the dry sample, thus offering a chance to correct any mistakes in weights before the samples have been discarded.

A table could be made showing the inches of water in a soil column for different size cutters and different weights of water. Using the table, the longest part of the computations would be in writing the answer. A slide rule solution is well within the accuracy required and would be equally as fast as using the table. If the cutter is made so that its diameter is 0.880 in, the tube constant, *c*, will be 0.1. Then to find the inches of water no computations would be necessary; the decimal would be simply moved one place to the left.

I have used the method of correction as explained and I believe it to be a logical and good correction. In my opinion, fast, inexpensive, and accurate data can be obtained by using this direct method of computing and correcting the equivalent depth of water in a soil column.

Ground Water in Drainage Design

(Continued from page 289)

Then the total pickup of base flow in the gaged reach is the sum of the contribution from the west area plus the east area, or 0.8 + 2.1 = 2.9 cfs. As shown by Table 2, the current-meter discharge measurements indicate the net pickup in the reach as 1.3, 2.5, 2.5, or 3.7 cfs, with an average for four trials of 2.5 cfs.

The coefficients of transmissibility and storage determined by the application of the drain formula compare favorably with the geologic and hydrologic checks that are available. It is indicated that under favorable conditions the drain formula permits the estimate of pickup or leakage within the limits of accuracy of the other measurement methods. The encouraging results obtained from this experiment in the application of the constant-discharge equation to drainage problems point to the desirability of testing constant-head equations for use on drainage problems and to the extension of these methods to the forecast of base flow from major stream basins. Research along these lines is in progress as a part of the cooperative water-resources investigation in Michigan.

BIBLIOGRAPHY

1 Wenzel, L. K.: Methods for Determining Permeability of Water-Bearing Materials. *U. S. Geol. Survey Water-Supply Paper* 887, p. 87 (1942).

2 Darcy, H.: Les Fontaines Publiques de La ville de Dijon, Paris (1856).

3 Theis, C. V.: The Relation Between the Lowering of the Piezometric Surface and the Rate of Duration of Discharge of a Well Using Ground-Water Storage. *Am. Geophys. Union Trans.*, p. 520 (1935).

4 Wenzel, L. K.: op. cit., p. 7.

5 Carslaw, H. S.: Introduction to the Mathematical Theory of the Conduction of Heat in Solids, 2d ed., *Dover Pub., New York*, p. 29 (1945).

6 Byerly, W. E.: An Elementary Treatise on Fourier's Series. Ginn and Co., Boston, Mass., pp. 81-94 (1893).

7 Jacob, C. E.: Correlation of Ground-water Levels and Precipitation on Long Island, New York. *Am. Geophys. Union Trans.*, p. 566 (1943).

8 Kirkham, Don: Artificial Drainage of Land: Stream-line Experiments—The Artesian Basin—II. *Am. Geophys. Union Trans.*, pt. 2, pp. 587-593 (1940).

9 Werner, P. W.: Notes on Flow-time Effects in the Great Artesian Aquifers of the Earth. *Am. Geophys. Union Trans.*, vol. 27, no. 5, p. 692 (October 1946).

10 Slichter, C. S.: Theoretical Investigation of the Motion of Ground Waters, *U. S. Geol. Survey 19th Ann. Rept.*, pt. 2, pp. 335-337 (1897-98).

11 Gardner, W., Collier, T. R., and Farr, D.: Ground Water, Fundamental Principles Governing its Physical Control, Part 1. *Utah Agr. Exper. Sta. Tech. Bull.* 252, pp. 21-24 (November 1934).

12 Carslaw, H. S.: op. cit., p. 153.

13 Theis, C. V.: Drawdown Caused by Withdrawal of Water From a Trench or Other Sink Involving One-dimensional Flow. Unpublished report.

14 Rogers, R. F., and Smith, W. G.: Soil Survey of Calhoun County, Michigan. *U. S. Dept. Agr., Bur. Soils* (1916).

15 Jacob, C. E.: Notes on Determining Permeability by Pumping Tests Under Water-table Conditions. *U. S. Geol. Survey*, mimeographed report (June 1944).

Two Editorials

TO THE EDITOR:

I SELDOM write fan letters but feel that your editorial, entitled "Engineering Philosophy," appearing in AGRICULTURAL ENGINEERING for March is worth several mailbags full of them. The need for an anchor is well stated in the first paragraph. Also, I like the question, and its implication, "Should a man be shielded from problems until he is 50 because he is too young to face them, and thereafter because he is too old?" I would place a period after the word "problems."

Your treatment of "More Than a Pseudo-Scientific Racket" is well worth a place on the editorial page. It provides a chuckle to those of us who are acquainted with the contestants and a very good statement on training for agricultural engineers.

Washington, D. C. W. M. HURST

Studies of Pressure-Head Losses in Concrete Risers and Alfalfa Valves

By Verne H. Scott

TESTS have been carried out recently in the hydraulics laboratory of the division of irrigation, University of California, Davis, to determine the head loss occurring in water passing through concrete risers and alfalfa valves. In some cases these losses are considerable and should be taken into account in the design of pipe line systems.

An engineer designing a concrete irrigation pipe system must consider several factors before he can determine the best arrangement for successful operation. Design problems usually fall into two classifications: determining the proper pipe line sizes, or determining the required height of stands, stacks, or division boxes needed to carry the flow of water in the pipe line. In either case, factors considered by the engineer are (1) the flow required at division points or outlets, (2) the head available or required in each length of pipe, which depends largely on the slope and lay of the land as determined by a topographic survey and (3) the amount of friction between the flowing water and the walls of the pipe. Another factor often overlooked or simply estimated is the head loss that occurs in a pipe line due to risers with outlet valves installed on the line. The following discussion describes the laboratory setup used and gives the data obtained from the study of losses occurring in risers.

In order to test the hydraulic properties of the riser, a 14-in dry-mix concrete supply pipe was laid on a sump floor in the laboratory, and a riser attached. The riser being tested was cemented to the top center of the 11th section, 31.5 ft from the entrance end of the supply pipe. A hole was carefully cut in the supply pipe of the same size as the inside diameter of the riser. The riser which extended 30 in above the top of the supply pipe, was shaped to fit snugly over the hole. The transition area on the inside between the pipe line and the riser was worked smooth by hand with neat cement. A metal-lined ponding basin in which water could be controlled to regulate submerged conditions was built around the riser.

Water was pumped through the laboratory water distribution system to the entrance of the supply pipe. Measurements on a calibrated 8-in flow nozzle or a 12-in orifice plate determined the rate of flow. At various locations on the supply pipe, and at the top and bottom of the riser, manometer connections (Fig. 1) of ¼-in copper tubing transmitted the local pressure via rubber tubing to glass tubing mounted on a board on the side of the ponding basin. This made it possible to record rapidly differentials in pressure head at all points in the system.

This paper was prepared expressly for AGRICULTURAL ENGINEERING.

VERNE H. SCOTT is junior irrigation engineer, University of California, Davis.

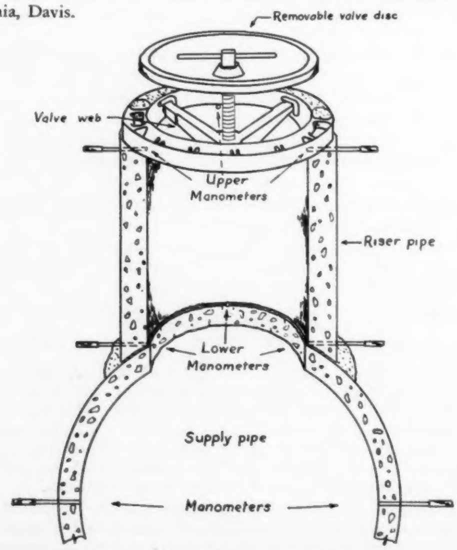


Fig. 1 Typical riser and alfalfa valve with manometers used in the study of pressure-head losses

Test Procedure. Eight, 10, and 12-in risers, the sizes most commonly used in irrigation practice, were tested. For each size of riser a series of six tests were conducted to determine the head loss for various rates of flow with riser conditions as follows:

Test 1 Riser unobstructed (without valve web).

Test 2 Riser unobstructed and valve seat submerged to various depths.

Test 3 Riser with web inserted in valve seat.

Test 4 Riser with web inserted in valve seat and valve seat submerged to various depths.

Test 5 Riser with web inserted in valve seat and the valve disk adjusted to various openings, i.e., the area between the bottom face of the valve disk and the top of the valve was varied.

Test 6 Riser with web inserted in valve seat and the depth of submergence changed for a range of valve openings.

Determinations of the pressure-head loss were made in each test for various rates of flow. Measurements of the loss were obtained from the manometer readings. This loss was equal to the difference between the average pressure head in th supply pipe before entering the riser and the average pressure head at the outlet of the riser (Fig. 1, upper manometers). In tests 1 and 3 the only variable condition was the rate of flow. In tests 2 and 4, for each rate of flow the depth of submergence was increased in 1.4-in increments. In test 5 the valve opening was varied in ½-in vertical increments. In test 6 the valve openings were identical to those in test 5, but the valve was submerged to various depths.

Discussion of Results. Head loss was plotted against rate of flow in each test for the three sizes of valves. Fig. 2 presents the results of these tests. The equations of the curves representing the points in this figure were calculated and are as follows; (in these equations, h = head loss in inches, and Q = rate of flow in cubic feet per second):

Test	8-in riser	10-in riser	12-in riser
1	$h=2.16Q^{2.11}$	$h=0.76\ Q^{2.22}$	$h=0.349Q^{2.29}$
2	$h=2.07Q^{1.95}$	$h=0.69\ Q^{2.39}$	$h=0.293Q^{2.52}$
3	$h=2.61Q^{1.97}$	$h=0.896Q^{2.19}$	$h=0.416Q^{2.30}$
4	$h=2.54Q^{2.20}$	$h=0.854Q^{2.23}$	$h=0.384Q^{2.33}$
5	$h=2.79Q^{2.12}$	$h=0.974Q^{2.05}$	$h=0.416Q^{2.61}$
6	$h=2.76Q^{1.98}$	$h=1.022Q^{2.05}$	$h=0.472Q^{2.13}$

A comparison of head-loss values (Table 1) between tests 1 and 3 for all three sizes of valves shows an increase in loss by inserting the web in the valve seat. At 0.5 cfs this increase amounted to 0.16 in for the 8-in riser, 0.04 for the 10-in riser, and 0.01 for the 12-in riser, however, at 2.0 cfs this increase amounted to 0.9 in, 0.55 in, and 0.35 in, respectively.

An attempt was made to reduce this web-loss effect by designing a more streamlined web. Such a web was made and tested on the 8-in valve. A small reduction in loss was noted. A comparison between values for the riser without the web and with the web showed that the head loss for flows of 0.5, and 1.0, 1.5 and 2.0 cfs was increased by 0.17, 0.45, 0.75 and 0.80 in respectively, by insertion of the web. For the same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flows the increase in loss attributed to the streamlined web was 0.05, 0.25, 0.45, and 0.70 in.

The data indicate that submergence may be beneficial in reducing head loss to some extent (Table 1, comparison of values from tests 2 and 4 with 1 and 3 for each riser). Exceptions to this were noted at low flows. The magnitude of the reduction was not great, and when this effect did occur, it was apparent as soon as the outlet of the valve was submerged. When the values of head loss for a steady flow were plotted against depth of submergence, no change was noted in the loss for additional depths beyond initial submergence.

Table 1. Comparison of Pressure-Head Loss for Quantities of Flow in 8, 10, and 12-in Alfalfa Valves and Risers

	Quantity of flow, cfs			
Test	0.5	1.0	1.5	2.0
		8-in (Head loss, in)		
1	0.50	2.26	5.08	9.30
2	0.53	2.03	4.55	8.00
3	0.66	2.60	5.80	10.20
4	0.56	2.55	6.20	11.15
5	0.64	2.77	6.60	12.00
6	0.69	2.75	6.18	10.80
		10-in		
1	0.16	0.75	1.86	3.55
2	0.13	0.69	1.85	3.62
3	0.20	0.89	2.20	4.10
4	0.18	0.84	2.10	4.00
5	0.23	0.98	2.25	4.05
6	0.25	1.01	2.33	4.20
		12-in		
1	0.07	0.35	0.88	1.70
2	0.05	0.30	0.82	1.68
3	0.08	0.42	1.05	2.05
4	0.07	0.38	0.99	1.94
5	0.08	0.47	1.15	2.25
6	0.11	0.47	1.12	2.07

In test 5 where the valve opening was changed, and in test 6 where the depth of submergence was altered for various valve openings, no significant change could be detected in the head loss as these changes were made. Consequently, the head loss for any flow in test 5 represented an average of the differences between pressure-head conditions in the pipe line and at the top of the riser for a range of valve openings, and in test 6 for a range of valve openings and varying depths of submergence.

The restriction of the valve opening by closing down the valve disk resulted in slight increases in the amount of head loss. Comparison of values between tests 3 and 5, and 4 and 6 (Table 1) for the three sizes of valves tested shows that for practically every discharge some increase in head loss occurred when the valve disk restricted the opening. The values ranged from 0.01 to 2.20 in.

Since a sudden loss of pressure head occurred in the transition from the pipe line to the riser, computations were made to determine what per cent of the observed pressure-head loss could be accounted for by the calculated theoretical velocity-head differential, the difference between the velocity head in the supply pipe and velocity head in the riser. Results from all the tests show that the theoretical velocity head is from 40 to 80 per cent of the recorded drop in pressure. It is probable that the remaining percentage is accounted for by turbulence and friction loss at the entrance to the riser.

CONCLUSIONS

It is apparent from these data that the pressure-head loss for discharge rates within the usual range of irrigation practice for the sizes of risers and valves tested is not large. For an 8-in riser and valve the loss that could be expected for discharges of 0.6 to 0.9 cfs would be 0.07 to 2.8 in; for the 10-in with 1.3 to 1.7 cfs, a loss of 1.1 to 3.0 in; and for the 12-in with 2.0 to 2.5 cfs, a loss of 2.0 to 3.2 in. However, if larger quantities of water are required, losses may become an important factor. It should be pointed out that the loss for various rates of flow in these tests probably represents a minimum value since the test apparatus was installed with greater care than that exercised by commercial pipe layers. Therefore, it may be reasonable to make an additional allowance for field installations.

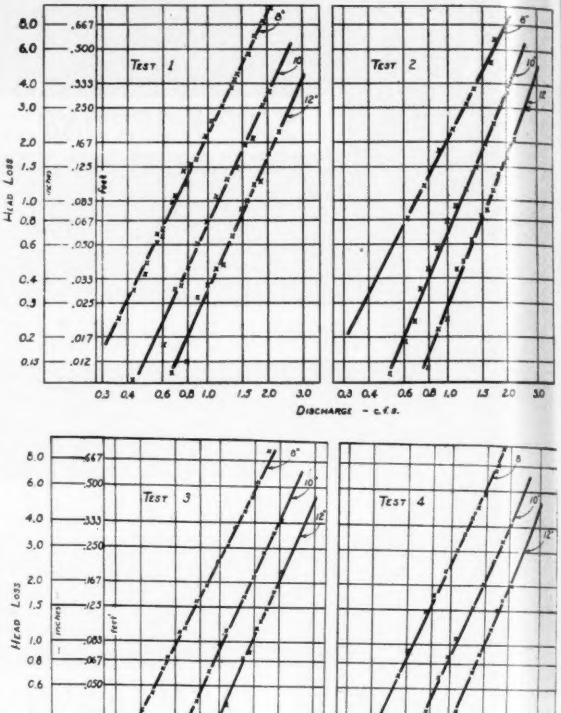


Fig. 2 Relationship between head loss and discharge in 8, 10, and 12-in concrete risers and alfalfa valves under the following conditions: Test 1, riser unobstructed (without valve web); test 2, riser unobstructed and valve seat submerged to various depths; test 3, riser with web inserted in valve seat; test 4, riser with web inserted in valve seat and valve seat submerged to various depths; test 5, riser with web inserted in valve seat and valve disk adjusted to various openings; test 6, riser with web inserted in valve seat and the depths of submergence changed for a range of valve openings

NEWS SECTION

Sprinkler Irrigation Conference

THE Committee on Irrigation of the American Society of Agricultural Engineers will sponsor a one-day conference on Sprinkler Irrigation on the day (June 22) following the Society's 43rd Annual Meeting to be held at Washington, D. C., June 19-21. The purpose of the conference is to arrange a general get-together of manufacturers, distributors, research and extension workers, and users of sprinkler irrigation equipment, for an exchange of ideas. The general subject of the conference will be "How Can We Advance the Art of Sprinkler Irrigation?" A special program is being arranged. The conference will be held in the District Room, Statler Hotel, Washington, June 22. Further details may be obtained from ASAE, St. Joseph, Michigan.

North Atlantic Section Meets in August

THE program committee of the North Atlantic Section of the American Society of Agricultural Engineers announces a preliminary program for the annual section meeting to be held August 28 to 30 on the campus of the University of New Hampshire at Durham.

At the opening session on the forenoon of August 28 three addresses have been scheduled by well-known speakers, including J. L. McCaffrey, president, International Harvester Co.; R. R. MacLeod, commercial manager, western div., Niagara Mohawk Power Corp., and a third speaker on a subject related to the development of the New England area.

The afternoon of August 28 will be devoted to three concurrent technical programs. The farm machinery program will feature equipment for weed control, design of hay blowers, and power and machinery research in Canada. The topics for the farm structures program will be pen stabling, milking parlor, and dairy stall design. A joint soil and water and rural electric program will feature types and use of irrigation equipment, water supply for irrigation, and pumping for supplemental irrigation.

Following the afternoon program there will be a tour of the University of New Hampshire campus and a field trip to a nearby drainage project.

A general session will be held during the evening of August 28 devoted to the subject of farm safety, with C. L. Hamilton, agricultural engineer, National Safety Council, as the principal speaker. Another feature of the evening will be a motion picture on the construction of the largest poultry house in the country, which accommodates 50,000 laying birds.

The forenoon of August 29 will include three concurrent technical programs. The power and machinery subjects will include current power and machinery research in progress, the retail dealer's function in modern mechanization, and economics of farm mechanization. The soil and water program will include discussion on the effect of rainfall characteristics on soil erosion, stream bank erosion, and the design of farm ponds for the Northeast. It is also possible that this program will include a paper on the Passamaquoddy Project. A joint farm structures and rural electric program will feature a paper on keeping accurate records of temperature, humidity, pressure and related facts on research projects, also the need of automatic controls and related subjects. The subjects of mow hay curing, small electric pasteurizers, and automatic egg-collecting are also tentatively planned for this program.

The afternoon session of August 29 will feature a program sponsored by the ASAE Committee on Youth Activities, and will be followed by the business session of the Section.

The annual Section banquet held on the same evening will include a brief observance of the 25th anniversary of the organization of the North Atlantic Section and suitable recognition of the charter members. Lawrence Whittemore, president, Brown Co., paper manufacturers of Berlin, N. H., has been secured as the dinner speaker.

The forenoon of August 30 will be devoted to a general technical session featuring the subject of grassland farming in the Northeast, which will be followed by contributions of the four technical groups of the Section.

The location of the meeting one of the scenic beauty spots of the Northeast and is close to the White Mountains, inland lakes, and the seashore. The occasion will provide many members an opportunity to combine business with a vacation.

A.S.A.E. Meetings Calendar

June 19-21 — ANNUAL MEETING, Hotel Statler, Washington, D. C.

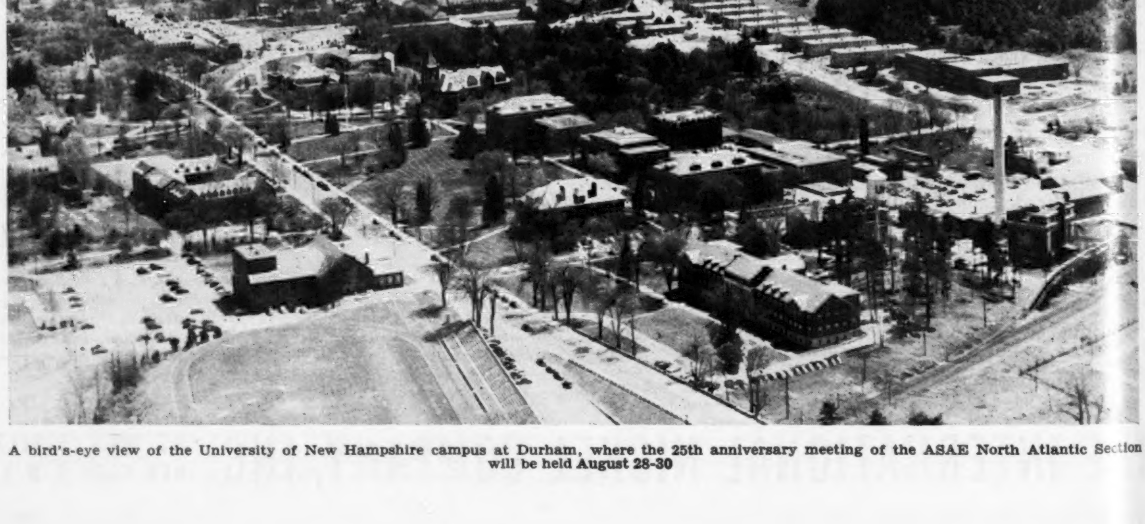
August 28-30—NORTH ATLANTIC SECTION, University of New Hampshire, Durham

October 19 and 20 — PACIFIC NORTHWEST SECTION, Yakima, Wash.

December 18-20 — WINTER MEETING, The Stevens, Chicago, Ill.

Hillman New Chairman Virginia Section

V. R. HILLMAN, executive officer, Virginia State Soil Conservation Committee was elected the new chairman of the Virginia Section of the American Society of Agricultural Engineers at the annual meeting held at Roanoke, April 21 and 22. He succeeds G. W. Halsey. Other officers for the ensuing year elected (Continued on page 298)



A bird's-eye view of the University of New Hampshire campus at Durham, where the 25th anniversary meeting of the ASAE North Atlantic Section will be held August 28-30

NEWS SECTION

(Continued from page 296)

at the meeting included three vice-chairmen of the Section—U. F. Earp, agricultural engineering dept., Virginia Polytechnic Institute; R. J. Blair, agricultural engineer, Appalachian Power Co., and R. B. Davis, Jr., Virginia farmer. J. L. Calhoun, associate extension agricultural engineer, Virginia Polytechnic Institute, was elected secretary-treasurer of the Section.

Ninety ASAE members and guests were registered at the meeting, which was opened on the afternoon of April 21 by G. W. Halsey, Section chairman. The program for the opening session included papers on economic considerations in soil and water conservation by T. S. Buie, regional director of SCS; on application of the forage harvester by E. W. Hamilton, Allis-Chalmers Mfg. Co.; on recent developments in farm buildings and rural housing research by Wallace Ashby, USDA agricultural engineer, and U. F. Earp on the design and construction of the farm refrigerator.

The Section dinner held on the evening of April 21 was featured by an illustrated lecture on progress in better living by L. F. Livingston, manager, extension division, E. I. duPont de Nemours & Co.

C. E. Seitz, head, agricultural engineering dept., Virginia Polytechnic Institute, presided at the forenoon session on April 21. Speakers at this session included L. G. Samsel, J. I. Case Co., who discussed new developments in haying equipment; Dr. M. L. Nichols, chief of research, Soil Conservation Service, who talked on field utilization of recent developments in soil and water research, and W. P. Judkins, head of the horticultural department, Virginia Polytechnic Institute, who talked on the importance of water in fruit production.

(News continued on page 300)

Personals of A.S.A.E. Members

William M. Cade, formerly employed for three years in tractor design and development work at the John Deere Tractor Works in Dubuque, Iowa, and for the past year design engineer of the French & Hecht division of the Kelsey-Hayes Wheel Co., Davenport, Iowa, has been promoted to the position of chief engineer of the Division.

Roy C. Ingersoll was elected president of the Borg-Warner Corporation at a recent meeting of the Corporation's Board of Directors. He has served as a vice-president of the Corporation since 1936, during which period he has also been president of the Ingersoll, Franklin and Calumet steel divisions, and the operating head of five plants and mills in Illinois, Indiana, Michigan, and Pennsylvania. Under his supervision the steel divisions of Borg-Warner have attracted industry-wide attention in the production and heat-treating of steel. To Mr. Ingersoll's credit is the development under his direction of the heat-treated disk and the installation of equipment to produce this disk in quantities to care for the needs of the farm equipment industry. Mr. Ingersoll has served as president of the Illinois Chamber of Commerce, and since 1941 has been a director and vice-president of the U. S. Chamber of Commerce.

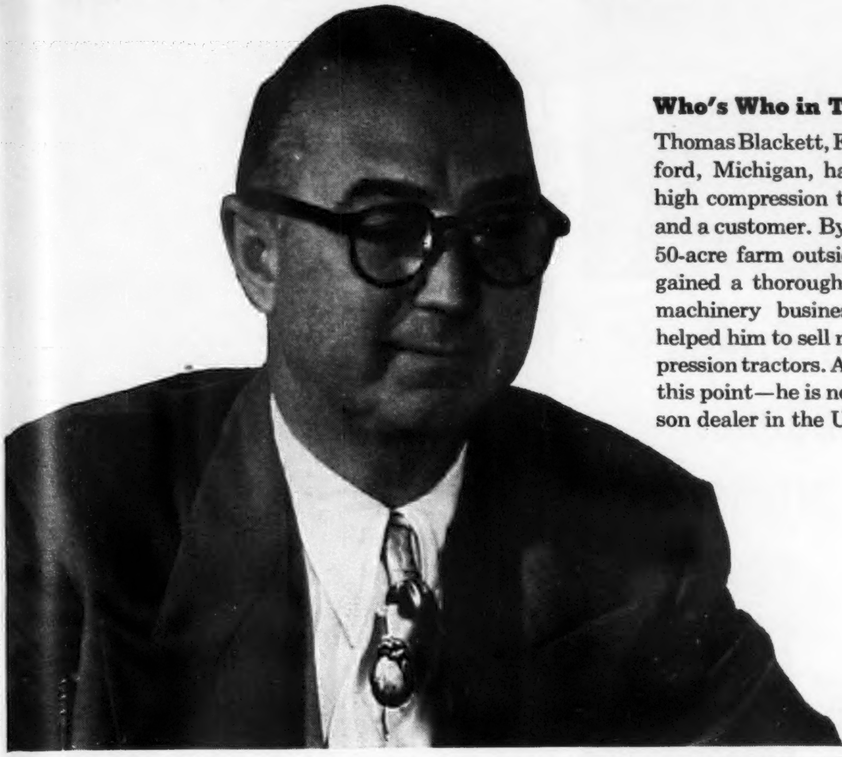
Robert R. Owen recently returned to Honolulu to become head of the department of agricultural engineering of the Pineapple Research Institute of Hawaii. He succeeds Dr. E. G. McKibben, who has accepted the position of director of the Tillage Machinery Laboratory of the U. S. Department of Agriculture at Auburn, Ala. For the past year, Mr. Owen has been research engineer with the Grasselli Chemicals Department of the E. I. duPont de Nemours & Co., Wilmington, Del. Just prior to his employment with duPont, Mr. Owen was an agricultural engineer for over three years with the California Packing Corp. in Hawaii. He was born in Arizona and was graduated from the University of California with a degree in mechanical engineering with an agricultural engineering option. During the war he saw service in various engineering activities and reached the rank of major.

Otto Schnellbach, consulting engineer at Baden, Germany, was recently appointed secretary of the Max-Eyth-Gesellschaft zur Forderung der Landtechnik, the German counterpart of ASAE. It is proposed to move the headquarters of the society to Frankfort am Main where it will be in close touch with other German organizations of agriculture, that is, the Deutsche Landwirtschafts-Gesellschaft, the Kuratorium fur Technik in der Landwirtschaft, the Landmachinenverband, the Hauptgemeinschaft des Landmachinenhandels und-Handwerks.

LeRoy Shirley is now sales promotion supervisor at the Nashville, Tenn., branch of the International Harvester Co., having been advanced from the position general line service manager for the Company in South Carolina.

Carlton L. Zink recently resigned as manager of the tractor tire division, tire engineering department, Firestone Tire and Rubber Co., to accept appointment as a staff member of the product research department of Deere and Co., Moline, Ill.

Published by the **Ethyl Corporation** to help promote the most efficient type of farm power.



Who's Who in Tractor Sales . . .

Thomas Blackett, Ferguson dealer of Waterford, Michigan, has learned plenty about high compression tractors as both a dealer and a customer. By owning and operating a 50-acre farm outside of Waterford, he has gained a thorough knowledge of the farm machinery business which, in turn, has helped him to sell more and more high compression tractors. A look at the record proves this point—he is now the 8th largest Ferguson dealer in the U. S.

"High compression is winning me new friends every day,"

Says ***Thomas Blackett***

Ferguson dealer of Waterford, Michigan

"Farmers look to tractor dealers for sound advice—and I don't hesitate to tell them that they'll do better with a high compression tractor. I know my customers will like the *extra power, economy* and *smooth performance* that a high compression engine delivers. And they will also appreciate the other benefits of gasoline-operated tractors—quick starting, fast warm-ups and clean burning of fuel.

"When I recommend a new high compression Ferguson tractor to a farmer, I know I'm helping him—as well as myself. The farmer gets a tractor that can work more acres per day and can get his work done on time. I, in turn, get a customer who's sure to be satisfied with the tractor I've sold him—a customer that will continue to deal with me because he has confidence in what I tell him."

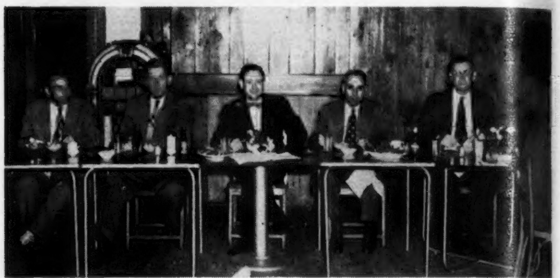
Today more than eight out of ten farmers prefer gasoline as a fuel, and dealers everywhere are selling with this trend—recommending tractor models that have powerful, economical, high compression engines.

NEWS SECTION

(Continued from page 298)

J. B. Wilson Heads Alabama Section

J. B. WILSON, a consultant to Dearborn Motors Corporation, and formerly extension agricultural engineer for Alabama, was elected chairman of the Alabama Section of the American Society of Agricultural Engineers for the year 1950-51, at the spring meeting of the Section held at Gulf Shores, Ala., April 13 and 14. He succeeds W. A. Womack. The section also elected M. B. Penn, agricultural engineer, Alabama Power Co., as the new vice-chairman of the Section. J. L. Butt, assistant agricultural engineer, Alabama Agricultural Experiment Station, was re-elected secretary of the Section.



This picture shows the group seated at the speakers table at the ASAE Alabama Section dinner April 13. *Left to right:* J. L. Butt, Section secretary; W. A. Womack, retiring Section chairman; A. J. Tully, U. S. District Attorney, Mobile, dinner speaker; F. A. Kummer, head, agricultural engineering department, Auburn Polytechnic Institute, and M. B. Penn, Section vice-chairman-elect

Thirty-six ASAE members and guests attended the meeting. Participating in the program were R. E. Jezek, associate agricultural engineer, USDA Tillage Machinery Laboratory at Auburn, who discussed the development of tung harvesting equipment; J. I. Davis, Jr., general manager, Southeastern Liquid Fertilizer Co., who talked on anhydrous ammonia as a source of nitrogen for farm crops; E. H. Wilson, agriculturist, American Cyanamide Co., who dealt with the subject of factors influencing defoliation of cotton; D. W. McConnell, McConnell Sales Engineering Co., who talked on heating units for seed driers; and Hurst Mauldin, Alabama Power Co., who demonstrated the factors essential to proper illumination.

At the section dinner held the evening of April 13, the principal speaker was Albert J. Tully, U. S. district attorney at Mobile, Ala., who spoke on the subject of water pollution, pointing out the need for keeping streams, rivers and lakes clean in the interest of health, game animals and fish, as well as natural beauty.

Davis New Chairman Georgia Section

J. IRWIN DAVIS, SR., special representative, agricultural sales development division, Caterpillar Tractor Co., Albany, Ga., was elected chairman of the Georgia Section of the American Society of Agricultural Engineers for the ensuing year, at the Section's spring meeting held at Panama City, Florida, April 28 *(Continued on page 302)*

ASAE Georgia Section backs up fish story with evidence

NEWS SECTION

(Continued from page 300)

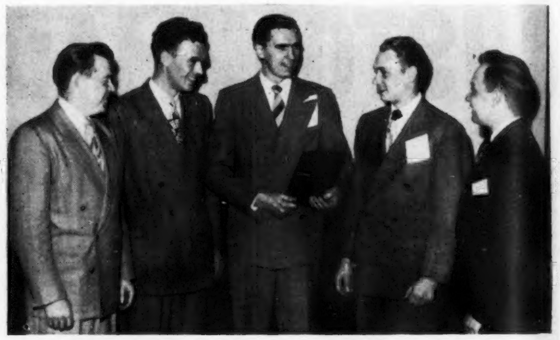
and 29. He succeeds J. W. Simons. The newly elected officers of the Section also include the vice-chairman, W. D. Kenney, agricultural engineer, Coastal Plain Experiment Station, Tifton, Ga., and the secretary, O. E. Cross, agricultural engineering dept., University of Georgia.

The main feature of the meeting was a day of deep-sea fishing in the Gulf of Mexico. In addition Section members present discussed ways and means of improving the Section activities and increasing attendance at its meetings as well as increasing the Section membership. It was decided that a special meeting would be held during the summer months at the Coastal Plain Experiment Station at Tifton. The fall meeting of the Section will be held at Athens, October 7.

Minnesota Student Branch Wins MFES Award

THE Minnesota Student Branch of ASAE made a repeat performance this year when it won first place for the second straight year in an exhibit competition sponsored by the Minnesota Federation of Engineering Societies. During the past two years the Federation representing all engineering societies has sponsored an engineering program and show in the Minneapolis Armory late in February, in which space has been made available for the student branches of each of the national engineering societies at the University to put on an exhibit. These exhibits are then judged by a committee appointed for that purpose.

The winning ASAE exhibit this year consisted of a model farm with certain soil and water conservation practices. These included an irrigation project in operation, a model of a tiling machine which ran and actually dug a trench in which tile were laid, and a sprinkler arrangement which caused rain to fall on the area at certain designated times. A cloud of spun glass was extended above the farmstead and thunderbolts were produced from a record to accompany the rain. In addition to the features mentioned previously terraces and grassed waterways were included in the design of the farm.



Five of the agricultural engineering students at the University of Minnesota shown receiving the plaque representing first prize in the MFES competition. Left to right, Arthur Kvamme, program chairman; Ardell Larsen, vice-president; Vernon Meyer, chairman of committee; Leonard Diederichs, president; and George Bowman, scribe. (Photograph by Marvin Nabben)

Investment in Farm Production Facilities

(Continued from page 273)

Borrowed capital must ordinarily be invested in ways satisfactory to the lender as well as the borrower, which requires a good prospect of security and return. Use of earned capital by the owner need only satisfy his own primary interests.

Those farmers who have earned surplus capital and who are inclined to do so, can render an important service to agriculture by indulging their natural desire for good buildings and equipment. By experimenting with investments in these items which may be near or beyond the borderline of economic justification in the strictest interpretation of the term, they can show where that borderline may be under proven competent management. It may be considerably beyond the profitable investment frontier for average or poor farm management. They can also provide valuable field or service tests of new improvements and do considerable to show what further improvements in farm buildings and equipment may be desirable and possible. They can afford to place a high value on human time and human life, and to demonstrate its meaning in terms of good farm living. Who can say what represents overinvestment of available capital in contributions to human progress?

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Abney, Fred K.—Owner, Abney Sprinkler Irrigation Equipment. (Mail) 401 E. Champion St., Edinburg, Tex.

Breeden, R. G.—Secretary-manager, Insulating Siding Assn. 530 Echo Lane, Glenview, Ill.

Broome, Joseph H. — Application engineer, government projects office, Minneapolis-Honeywell Regulator Co., 1919 K St., N. M., Washington, D. C.

Cornett, James B.—Student, University of Tennessee. (Mail) 1530 Maury St., Alcoa, Tenn.

Davis, E. Tyler—Assistant to vice-president, Wheeling Steel Corp., Wheeling, W. Va.

Edinburg, Norman M.—Director and engineer, Pan African Industries, Ltd., Pan Africa House, Troye St., Johannesburg, S. A.

Feather, Donald N.—Field instructor, education dept., Dearborn Motors Corp., 15050 Woodward Ave., Detroit 3, Mich.

Jennings, David A. D.—R. R. 2, Powell, Tenn.

Kernan, George J.—Chief engineer, Oregon State Game Comm., Portland, Ore. (Mail) 3404 N. E. 42nd St.

Livingston, Lanier S.—Assistant county supervisor, Farmers Home Administration, USDA. (Mail) 200 N. Brooks St., Manning, S. C.

Lucas, Raymond D.—Box 224 A, R. R. 6, New Orleans, La.

Menon, A. G.—Director of agricultural machinery, Ministry of Agriculture, Govt. of India, New Delhi, India

Nirmal, T. H.—Supervisor, agricultural implement sales, Allahabad Agricultural Institute, Allahabad, India

Pattyn, Martin J.—Extension agricultural engineer, University of Kentucky, Lexington, Ky. (Mail) 213-3 Shawneetown

Prince, Ralph P.—Farmer, Aetna, Tenn.

Rebentisch, John A.—Graduate student, Louisiana State University. (Mail) 2106 Ferndale Ave., Baton Rouge 15, La.

Seabrook, John M.—General manager, Seabrook Farms Co., Bridgeton, N. J.

Sonneman, Paul R.—Chief engineer, product engineering dept., International Harvester Co., 201 First St., Rock Falls, Ill.

Srivastava, A. P.—Assistant agricultural engineer, U. P. Govt. (Mail) 6 Elgin Rd., Allahabad, U. P. India

Wulkan, Lynn—District field supervisor, Farm Engineering Sales, Inc. (Mail) Hector, Minn.

TRANSFERS OF MEMBERSHIP GRADE

Dugal, Gordon E.—Head, agricultural engineering dept., Southwestern Louisiana Institute, Lafayette, La. (Mail) P. O. Box 475 L. S. I. Station (Associate to Member)

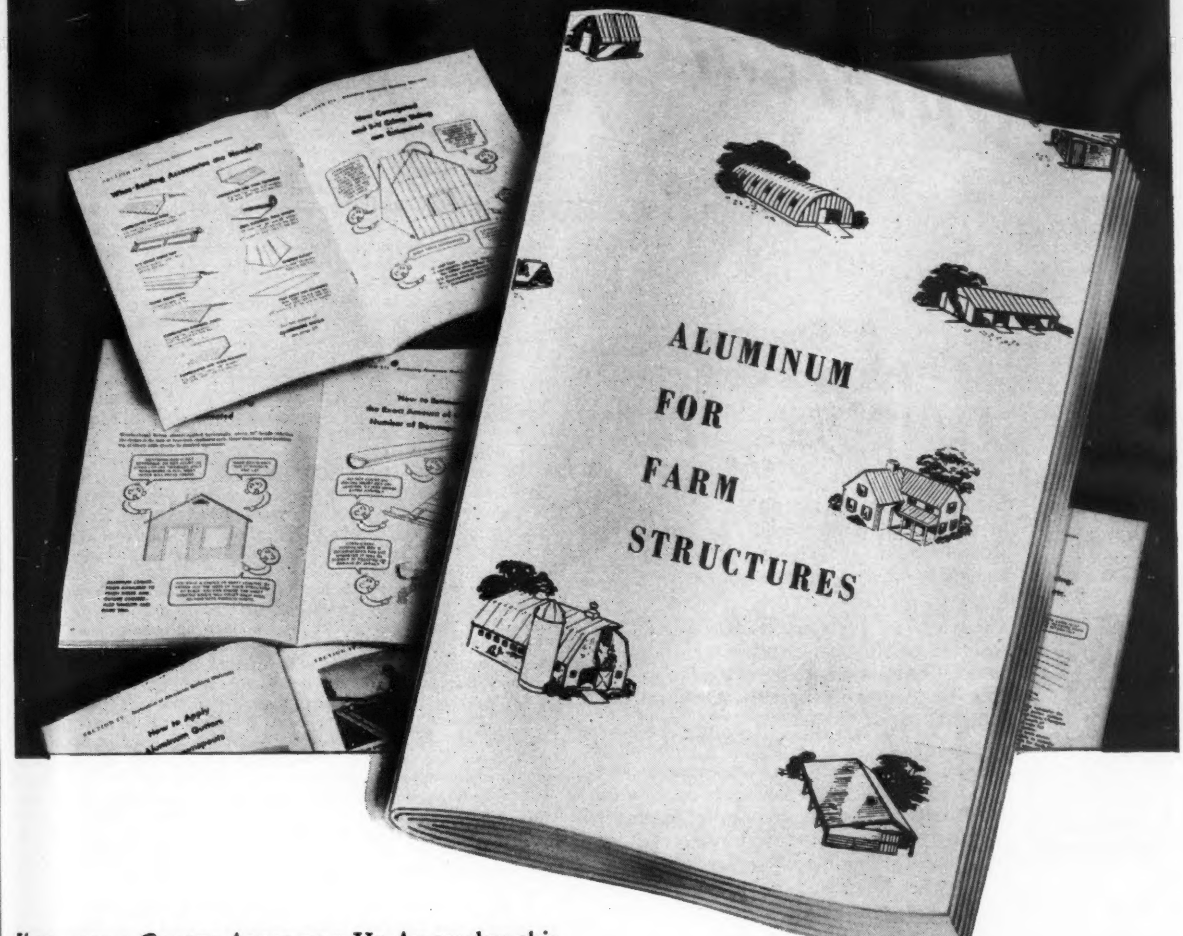
McWhorter, John C.—Associate professor of agricultural engineering, Mississippi State College, Box 387, State College, Miss. (Junior Member to Member)

Norris, Karl H.—Associate agricultural engineering, (BPISAE) USDA. (Mail) 5807 Seminole St., Berwyn Heights, Md. (Junior Member to Member)

PROFESSIONAL DIRECTORY

RATES: Announcements under the heading "Professional Directory" in AGRICULTURAL ENGINEERING will be inserted at the flat rate of $1.00 per line per issue; 50 cents per line to A.S.A.E. members. Minimum charge, four-line basis. Uniform style setup. Copy must be received by first of month of publication.

. . . that you may serve the Farmer better!



If you are a County Agent or a Vo-Ag teacher, this 64-page manual will reach you shortly. Prepared by Reynolds Farm Institute and reviewed by agricultural authorities, it will help you answer the many questions that arise as to the proper use of aluminum on the farm.

For additional farm help, fill out the coupon for FREE ALUMINUM ADAPTOR PLAN, showing how to use aluminum with all standard farm building plans. **Reynolds Metals Company, Building Products Section, Louisville 1, Ky. Offices in 32 principal cities.**

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Please send me your FREE Aluminum Adaptor Plan.

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REYNOLDS ALUMINUM

RESEARCH NOTES

A.S.A.E. members and friends are invited to supply, for publication under this heading, brief news notes and reports on research activities of special agricultural engineering interest, whether of federal or state agencies or of manufacturing and service organizations. This may include announcements of new projects, concise progress reports giving new and timely data, etc. Address: Editor, AGRICULTURAL ENGINEERING, St. Joseph, Mich.

USDA Notes on Psychroenergetic Laboratory, Industry Research Conference, Fertilizer Nomogram, and New Farmhouse Plans

Psychroenergetic Laboratory Findings. The Missouri Agricultural Experiment Station has recently issued two more reports in the series "Environmental Physiology with Special Reference to Domestic Animals". These data are based on work at the Psychroenergetic Laboratory, Columbia, Mo., in which the Missouri station and the three USDA bureaus (BPISAE, BDI, and BAI) cooperate, assisted by the Office of Naval Research. H. J. Thompson is the USDA agricultural engineer in charge of temperature and humidity measurement and control. The information obtained in these studies will be used to refine functional requirements for dairy cattle housing. The new bulletins are: Research Bulletin 449 — VI. Influence of Temperature, 50 to 0 F and 50 to 95 F, on Milk Production, Feed and Water Consumption and Body Weight in Jersey and Holstein Cows, by A. C. Ragsdale, D. M. Worstell, H. J. Thompson, and Samuel Brody, September 1949; and Research Bulletin 450 — VII. Influence of Temperature, 50 to 5 F and 50 to 95 F, on Heat Production and Cardiorespiratory Activities of Dairy Cattle, by H. H. Kibler and Samuel Brody, October 1949.

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Industry Research Conference. The sixth in a series of Agricultural Equipment Industry Research Conferences was held in the Memorial Union at Iowa State College, Ames, March 20, 21, and 22. Sponsored by the Agricultural Engineering Department of the Iowa Agricultural Experiment Station, the Farm Equipment Institute, and the BPISAE Divisions of Agricultural Engineering, this series of regional conferences was started to acquaint the farm equipment industry with research in progress and with results ready for use in farm machinery and equipment designs. Benefits of agricultural engineering research reach farmers in large part through prompt incorporation of results in new equipment models put on the market by manufacturers. The first Industry Research Conference was held at Beltsville in 1947.

Mr. Norton, farm machinery division staff member, presented one of the summaries of research under "Problems and Progress in Weed Control." He also gave a progress report for engineering on the National Weed Control Project. Mechanical implications of research results in conditioning and storing grain were discussed by W. V. Hukill of farm buildings and rural housing. Tests of sprayer equipment were reported by R. E. Larson, and progress with machines in the corn borer control program by Frank Irons, both of farm machinery. John Taylor, farm electrification staff member gave a paper on the use of electricity in corn borer control.

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Fertilizer Placement Project Contributes Nomogram. Available for use by research workers applying fertilizer or seed to small experimental plots is a nomogram to facilitate quick checks on calculations. Developed by Walter C. Hulburt, associate agricultural engineer of the USDA farm machinery division, the nomogram has been used effectively by the number of cooperators in the fertilizer placement project. The graph has two components — area and material. The area component has *length* and *width* scales in feet and *area* scale in square feet and acres. The material component has scales of *quantity* in pounds and *rates* in pounds per acre. Among the uses of the nomogram are: To fit row length to area available, to find size of plots in square feet or fractions of an acre when only dimensions are known, to check the amount of material weighed out for plots, and to check rates of machine application. Information Series No. 99, "A Nomogram for Checking Rates of Application of Fertilizer or Seed on Small Areas," includes the graph with detailed suggestions for its use and is available from the Agricultural Engineering Divisions.

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New Farmhouse Plans. USDA Leaflet No. 285, "Four Farmhouses for the South," announces that complete working drawings are available through the Plan Exchange Service for four house plans developed with special reference to needs of farm families in the South. Plans were prepared by Alabama Polytechnic Institute, North Carolina State College, Mississippi Cooperative Extension Service, and the BPISAE Division of Farm Buildings and Rural Housing.

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Information Series 101. The paper "Operation and Performance of Alfalfa Dehydrators in the Central United States," by Leonard G. Schoenleber which appeared in the May issue of AGRICULTURAL ENGINEERING, has been mimeographed as Information Series 101 of the Divisions of Agricultural Engineering, BPISAE, U. S. Department of Agriculture and may be obtained free upon request.

Compare the knot!

The Oliver wire tying mechanism is so simple in design you can thread the shuttles and knotter in less than 5 minutes! Units are enclosed . . . fully protected. Servicing is easy, too. To detach the knotter or shuttle gearbox, simply remove the four bolts that hold each in place.

Made by this New Automatic Baler

Compare the wire knot tied by the new, completely automatic Oliver Model 8 . . . *with all others!* Then figure out the savings in feet . . . and *dollars.*

This short, tightly twisted, firm-holding knot averages only 1½ inches in length. What's more, the knot is turned in—*toward the bale!* No scraggly ends protrude to tear clothing or flesh. There are no "clippings" or short pieces. *No wire is wasted.*

And, when it comes to baling speed, the Oliver Model 8 will equal the output of any automatic machine made! It's *tons per day* that determine a baler's real capacity!

Yes, *compare* the completely new Model 8 with all others. Examine the compact, simple tying mechanism. Inspect the tie. Check the sturdy, "straight through" frame construction, full-floating pick-up, synchronized feeding units, "big beat" feeder head and the "top shear" that produces sliced bales. The Oliver Corporation, 400 West Madison Street, Chicago 6, Illinois.

OLIVER

"FINEST IN FARM MACHINERY"

NEWS FROM ADVERTISERS

New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Aluminum for Farm Structures. The Reynolds Farm Institute, sponsored by the Reynolds Metals Co., recently published under the above title a 6x9-inch, 64-page illustrated bulletin with chapters on the properties of aluminum, description and uses of aluminum building products, estimating aluminum building materials, application of aluminum building materials, and other important farm uses of aluminum. Copies may be obtained on request to Reynolds Farm Institute, Box 1800, Louisville 1, Ky.

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Bendix Breakaway Coupling. The Pacific Division of Bendix Aviation Corp., North Hollywood, Calif., has announced a new, easy-to-clean breakaway coupling for connecting the hydraulic lines from tractor to implement, which can be connected and disconnected by hand with full pressure in the lines. Known as the Line-Link, it is unique in that the two mating sections can be slid back flush on the ends, permitting quick, easy cleaning in the field. The ease with which the units can be put together and taken apart is due to an exclusive built-in pressure lock feature. Another feature of this design is an extremely low-pressure drop. Mounting of the coupling offers wide flexibility. Complete information is available from the manufacturer.

A view of the Bendix breakaway coupling

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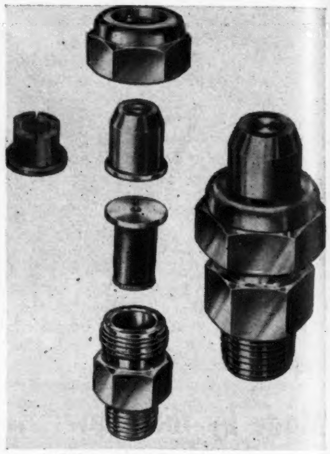
Delavan Spray Nozzle Tips. The Delavan Mfg. Co., Des Moines, Iowa, has announced a new type of agricultural nozzle which makes it possible to change from a flat spray to a cone spray by means of interchangeable nozzle tips. The exploded view in the illustration shows all parts of this completely interchangeable nozzle. Both the type CS cone spray and the type LS flat spray nozzle tips may be used with the same Delavan adapter and cap, or with any standard agricultural nozzle. The strainer is available with or without a ball-check device which is incorporated inside the strainer. The ball-check may be used with both cone and flat sprays. Because of the interchangeable feature, one nozzle with two tips will take care of practically all spraying needs on any farm.



Delavan spray nozzle tips

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American S. and W. Fencing Booklet. The agricultural extension bureau of the American Steel and Wire Co., U. S. Steel, subsidiary, Cleveland, Ohio, has recently published an 8-page booklet describing the role of fence as a productive tool of agriculture. It is a recognized fact that grassland farming, complemented with a well-balanced livestock program, pays big dividends by effectively controlling erosion and by maintaining the fertility of the soil. Fencing plays an important part in modern soil conservation and planned farm management programs through use of extended and rotated pastures. The booklet points out how good permanent fence permits livestock to do their own harvesting and fertilizing and enables the farmer to reduce production costs. Fencing sets the stage for crop and pasture rotation and for lower production costs, since it reduces labor and fosters production of fresh forage for all farm animals.

Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail; for further information see the issue of AGRICULTURAL ENGINEERING indicated:

POSITIONS OPEN: (1949): AUGUST — O-34-675, 34-678. SEPTEMBER — 0-84-682. NOVEMBER — O-127-690. (1950): JANUARY — O-189-692, 201-697. MARCH — O-262-700, 262-701, 253-703, 270-705. APRIL—O-284-707, 281-708, 297-710, 306-712. MAY — O-286-713, 308-714, 329-715, 342-716.

POSITIONS WANTED: (1949): MAY—W-258, SEPTEMBER—W-67-312, OCTOBER — W-111-316. DECEMBER — W-145-323, 14[illegible]-324, 151-325, 137-327. (1950): JANUARY — W-164-331, 175-334, 179-335, 177-337, 190-338. FEBRUARY — W-199-342, 214-343, 208-344, 213-349. MARCH — W-227-351, 247-352, 228-353, 256-355, 248-357, 257-359, 246-360, 268-361, 258-362. APRIL — W-289-363, 283-365, 255-367, 294-368, 299-369, 304-370, 249-372, 291-373, 293-374, 307-375. MAY — W-320-376, 327-377, 328-378, 312-379, 333-380, 325-381, 326-382, 338-383, 339-384, 349-385, 351-386, 341-387, 347-388.

NEW POSITIONS OPEN

DESIGNING ENGINEER to head planter and cultivator division in engineering department of a full line farm equipment manufacturer. Location Illinois. BS deg in agricultural or mechanical engineering and several years experience in designing, drafting, and layout work on cultivators, planters, middlebusters, and listers, including tractor-mounted and toolbar implements. Must be capable of supervising small group of assistant designers, draftsmen and mechanics in design and building of experimental farm machines. Opportunity up to individual. Age 25-45. Salary open. O-355-717

INSTRUCTOR to teach carpentry and building construction in the agricultural engineering department of a land grant university in the Southeast. MS deg in agricultural engineering, or equivalent. Must be industrious, good organizer, good natured, and cooperative. Teaching experience desirable. Opportunity for advancement up to rank of professor. Age 25-35. Salary $3200-4200, depending on qualifications, for 11 mo. O-379-718

AGRICULTURAL ENGINEER (assistant or associate) for research in power and machinery, chiefly development of special machines for Hawaiian crop operations; possibly limited teaching. Location Hawaii. MS deg in agricultural engineering, or equivalent, with thorough understanding of machine design. Additional training in irrigation and structures desirable. Experience in design, operation, and maintenance of agricultural machinery, and in irrigation and structures fields also desirable. Position requires ability to cooperate with other organizations and other usual personal qualifications for college and research work. Faculty housing on campus. Interview at ASAE Annual Meeting in Washington in June, or elsewhere immediately following. Salary $3780 or higher. O-393-719

DESIGN ENGINEER for agricultural machinery, with manufacturer on West Coast. Degree desirable, but experience is prime requirement. Opportunity for advancement. Must be able to provide good recommendations from former employers. American nationality. Age, under 40 preferred, but will also consider older applicants. Salary open. O-395-720

SENIOR DESIGN ENGINEER for work with large full-line farm equipment manufacturer. Location Iowa. Graduate engineer preferred. Minimum of 5 yr responsible and successful experience in design of farm machinery, particularly corn pickers or cotton pickers. Unusual opportunity for a really capable and ambitious engineer. Age 30-40. Salary open. O-407-721

NEW POSITIONS WANTED

DESIGN, sales, or service in power and machinery or rural electrification in public service or private industry anywhere in the United States. Willing to travel. BS deg in agricultural engineering, Kansas State College, January 1950. Wheat farming background. Worked on farm since graduation. Single. Age 22. No disability. Available now. Salary open. W-340-389

EXTENSION or management work in soil and water or farm management field, with manufacturer or in farming operation in Midwest, preferably Iowa or Minnesota. BS deg in agricultural engineering, June 1949, Iowa State College. Farm background. Conservation aide in Soil Conservation Service, summer 1948. Teaching in soil and water laboratory, spring quarter 1949. Since graduation superintendent of Ankeny (Iowa) Experimental Farm, supervising building construction and farm crews, and surveying for terracing, contouring, and drainage. War enlisted and commissioned service in Army Air Force, 2½-yr. Married. Age 27. No disability. Available now. Salary $3600. W-348-391

DESIGN, promotion, sales, service, or management, in power and machinery or farm structures field, with manufacturer, distributor, or consultant, any location. BS deg in agricultural engineering, May 1941, University of Georgia. Experience in diesel engineering, 5½ yr; sales engineering over 2 yr. Instructor in blueprint development and machine design in vocational school. War enlisted and commissioned service in Navy over 4 yr, with promotion to Lt., Sr. Grade, engineer. Single. Age 31. No disability. Available now. Salary $3000 min. W-366-392

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PERSONNEL SERVICE BULLETIN

(Continued from page 310)

DESIGN, development, or service in farm structures field, with federal agency or private industry, in Northeast. BS deg in agricultural engineering, 1950, University of Missouri. Experience as carpenter's helper and roofing mechanic one summer. Hired worker on farm one year. Herdsman and assistant instructor, N. Y. State Institute of Agriculture 6 mo. War enlisted service in Navy, 2 yr. Married. Age 26. No disability. Available now. Salary $3000 min. W-364-393

DESIGN, development, sales, or service in power and machinery or rural electric field, in private industry in South. BS deg in agricultural engineering, 1950, Louisiana State University. Farm background. Carpenter 3 mo. Part time work in agricultural engineering laboratory during senior year in college. War enlisted and cadet service in Navy 1½ yr. Married. Age 23. No disability. Available now. Salary open. W-380-394

EXTENSION, research, or teaching in power and machinery or farm structures, in college or experiment station, preferably in West. BS and MS degs in agricultural engineering, University of California. Research and teaching, University of California, 9 yr. Research, teaching, and extension, University of Idaho and New Mexico A & M College, 5 yr. Teaching agricultural engineering courses at junior college, 5 yr. Married. Age. 43. No disability. Available July 1. Salary open. W-384 395

DEVELOPMENT, service, or construction in farm structures field with private industry, preferably in Midwest. BS deg in agricultural engineering, 1950, Purdue University. General farm operation 4 yr. Equipment maintenance and distribution with steel erection engineers, 8 mo. War enlisted and cadet service in Army Air Corps, 2 yr. Married. Age 26. No disability. Available June 20. Salary $3000-4000. W-361-396

DESIGN, development, or research in power and machinery or product processing, with college, experiment station, manufacturer, processor, or farming operation, anywhere in the United States. Willing to travel. BS deg in agriculture, Lingnan University, China, 1938. BS and MS degs in mechanical engineering, 1949 and '50, State University of Iowa. Technical assistant on sugarcane plantation (production work) 1 yr. Associate research fellow in Tung Oil Research Institute, 3 yr. Farming operation on Seabrook Farms, N. J., 3 mo. Age 35. No disability. Available in September. Salary open. W-383-397

EXTENSION, teaching, research, sales, or service in farm structures or soil and water field, in public service or private industry, anywhere in the United States. BS and MS degs in agricultural engineering, 1949 and '50, University of Illinois. Grain and livestock farm work one summer. Drafting and field work 20 hr per week, last semester of senior year. Teaching and research in agricultural engineering department half time while taking graduate work. War enlisted service in Navy over 2 yr; radio and radar technician. Married. Age 24. No disability. Available August 1. Salary open. W-368-398

EXTENSION, teaching, research, or writing, in farm structures, soil and water, or rural sanitation field, in public service or private industry in United States or Canada. BS deg in agriculture, with major in agricultural engineering, Ontario Agricultural College, 1948. MS deg in agricultural engineering, University of Toronto, expected in September. General farm background, including operation for 10 yr. Two summers with implement manufacturer on assembly, tractor repair, and plant maintenance. Half time teaching and research during 2 yr graduate study. Enlisted and commissioned service 2 yr, RCAF; ratings of pilot officer and air navigator. Married. Age 29. No disability. Available July 1. Salary open. W-387-399

DESIGN, development, research, writing, or management in soil and water or land use and wildlife management, in public service or private industry, in United States or possibly elsewhere. BS deg in agriculture 1949, MS deg in agriculture to be completed shortly after Oct. 1, University of Florida. Farm background, 20 yr operation of own 100-acre fruit farm. Substation operation 2 yr with Manitee Ice and Coldstorage Co. Present work with Department of the Interior as project leader on land use from the standpoint of wildlife management. Married. Age 41. No disability. Available Oct. 1. Salary open. W-274-400

DESIGN and development in farm structures field, in public service or private industry, preferably in Midwest. BS deg in agricultural engineering, 1950, Purdue University. Part time work in research, drafting, and sales while in school. War enlisted service in Navy 2½ yr. Married. Age. 25. No disability. Available July 1. Salary open. W-369-401

RESEARCH, sales, or service in power and machinery or soil and water field in public service or private industry, anywhere in the United States. BS deg in agricultural engineering 1950, South Dakota State College. General farm background. War enlisted service in Army, 1 yr. Single. Age 24. No disability. Available now. Salary $3000. W-378-402

DESIGN, development, research or teaching in power and machinery field, with college, manufacturer, or farming operation, anywhere in United States, or possibly in India. BS deg in agricultural engineering, 1940, University of Nebraska. Farm background. Part time work at University of Nebraska, 6 yr. Test engineering at tractor works, 1 yr. Florida Public Health Service, 1½ yr. Soil Conservation Service 9 mo. Teaching in agricultural engineering field 4½ yr. Married. Age 33. Available July 1. Salary $3600, or equivalent with housing, etc. W-354-403

SALES or service in farm power and machinery field in public service or private industry, anywhere in the United States. BS deg in agricultural engineering, 1950, Louisiana State University. Farm background. General office work part time 4 yr. Attended Army service school and later instructed in electricity and equipment repair. War enlisted service 1½ yr. Single. Age 22. No disability. Available now. Salary open. W-394-404

New Bulletins

37 Years of Farm Electric Progress. Public Service Co. of Northern Illinois (Chicago). Pictures and text showing growth in numbers of farmers served, the extent to which electric power is used by individual farmers, and in the variety of farm uses to which the power is applied in territory served by the company, particularly since an agricultural engineer was hired in 1925 to stimulate this development.

Electric Fence Controllers, by John E. Nicholas. Progress report No. 14 The Pennsylvania State College, (State College, Pa., August, 1949). A summary of research on the operating characteristics of electric fence controllers and some of their component parts, with a view to locating weak points and opportunities for improvement.